MAINTENANCE MANUAL

for the

MODEL 139-WH3 BOMBARDMENT AIRPLANE

Issued June, 1938

(Covering airplanes numbered 775 to 794 and 796 to 814)

Notices:

1. Permission must be obtained before using any photographs or other material in this book for publication.

2. The specific model designation "139-WH3" is used to denote the particular airplanes built under the Netherlands Government Contract; whereas the general designation "139-W" includes all models of the 139-W series.

THE GLENN L. MARTIN COMPANY
BALTIMORE, MARYLAND
U.S.A.

INDEX

LIST OF ILLUSTRATIONS

SECTION I

INTRODUCTION

This book has been written to provide the Purchaser's Operating Personnel with complete instructions for the assembly, operation, and maintenance of the Martin Model 139-W Bombardment Airplanes. The Glenn L. Martin Company assumes no responsibility for parts rendered defective by operation or maintenance procedure contrary to the instructions contained herein.

The maintenance procedure for a number of items is dealt with in publications issued by the manufacturers of such items. Such publications are referred to in this Handbook when they contain instructions applicable to the specific installations in this airplane. Copies of several such publications are furnished with this handbook under separate cover. A complete list of the publications included will be found at the end of this voluem (Appendix II).

Materials and processes required to maintain these airplanes are designated herein by the number of the U.S. Government Specification covering such material. Copies of the specifications referred to will be found under separate cover titled "Detail Army and Federal Specifications for Model 139-W Handbook."

The full model designation and serial number of each airplane is stamped on the trade mark name plate located in the pilot's cockpit. Correspondence pertaining to a particular ship should mention the model and serial number. If a particular part is being discussed the part number should always be given, if possible. Identification plates will be found on all major assemblies.

As some of the parts used in this airplane are designated by "dash" numbers of drawings for previous models, the list of drawings in Appendix III should be consulted as a final check in determining the applicable drawing number. (These numbers are also shown in a Group Parts List furnished the purchaser of the airplanes.)

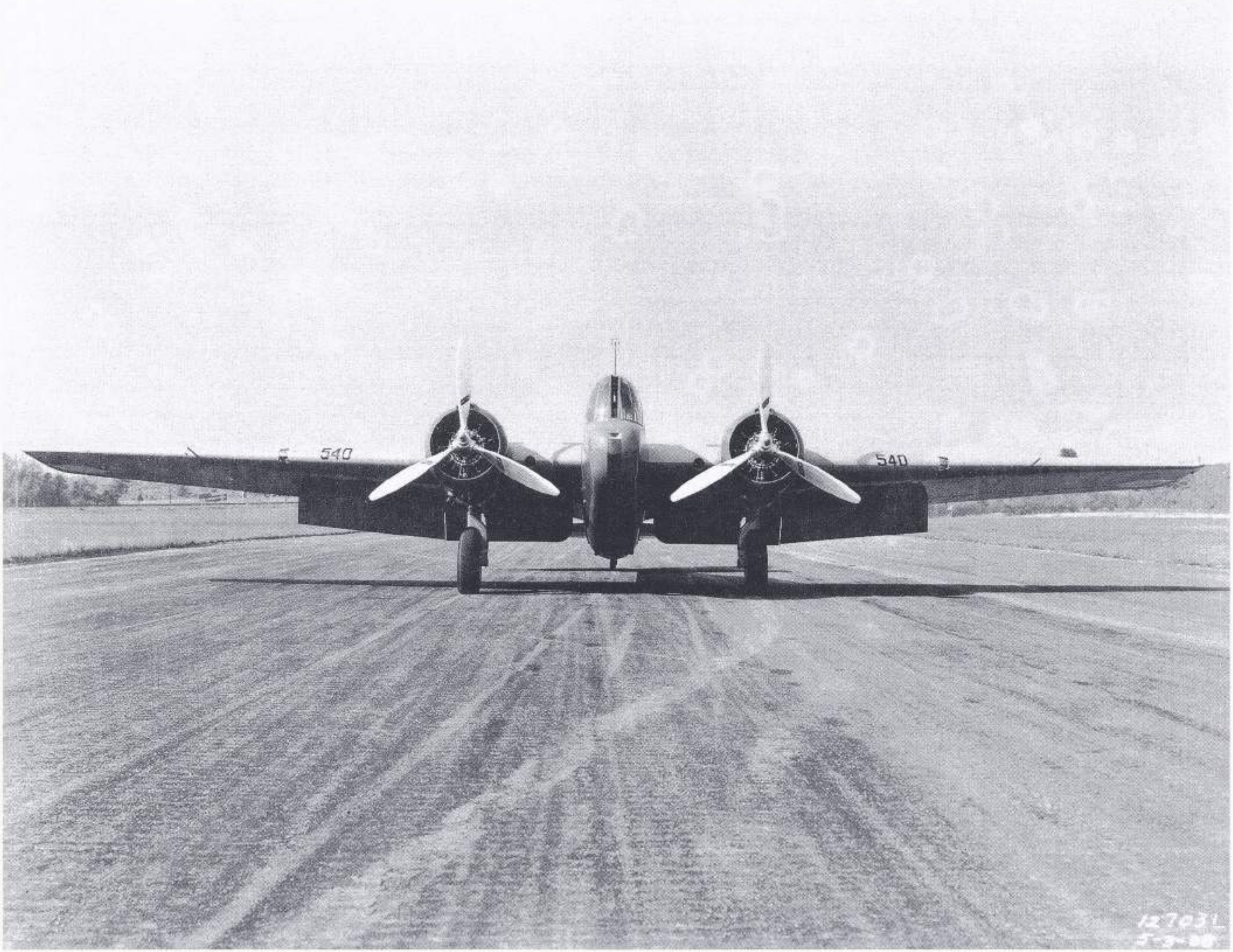


FIGURE 1 AIRPLANE - FRONT VIEW - FLAPS LOWERED

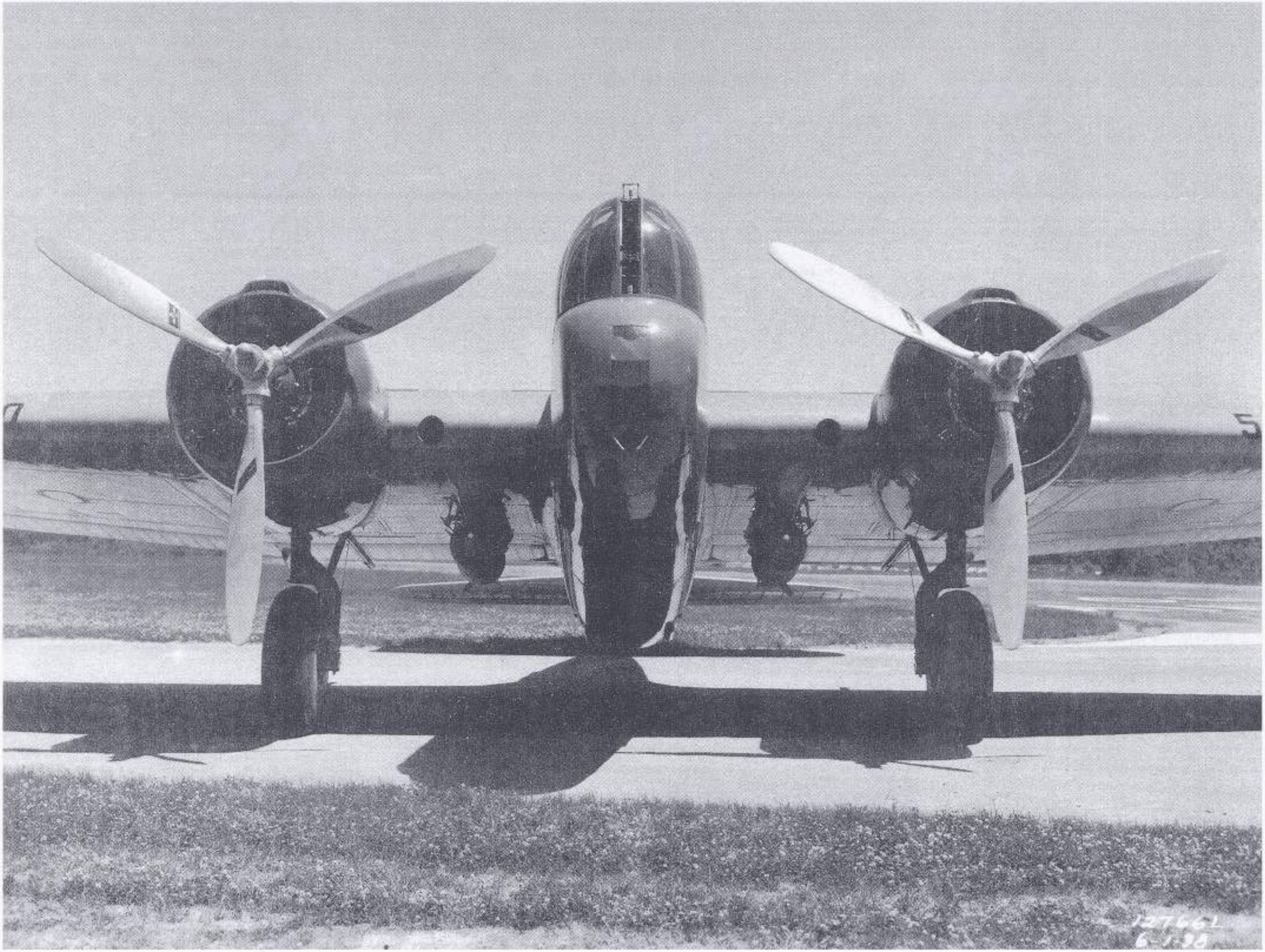


FIGURE 1A AIRPLANE - CLOSE-UP 600 LB BOMBS IN EXTERNAL RACKS

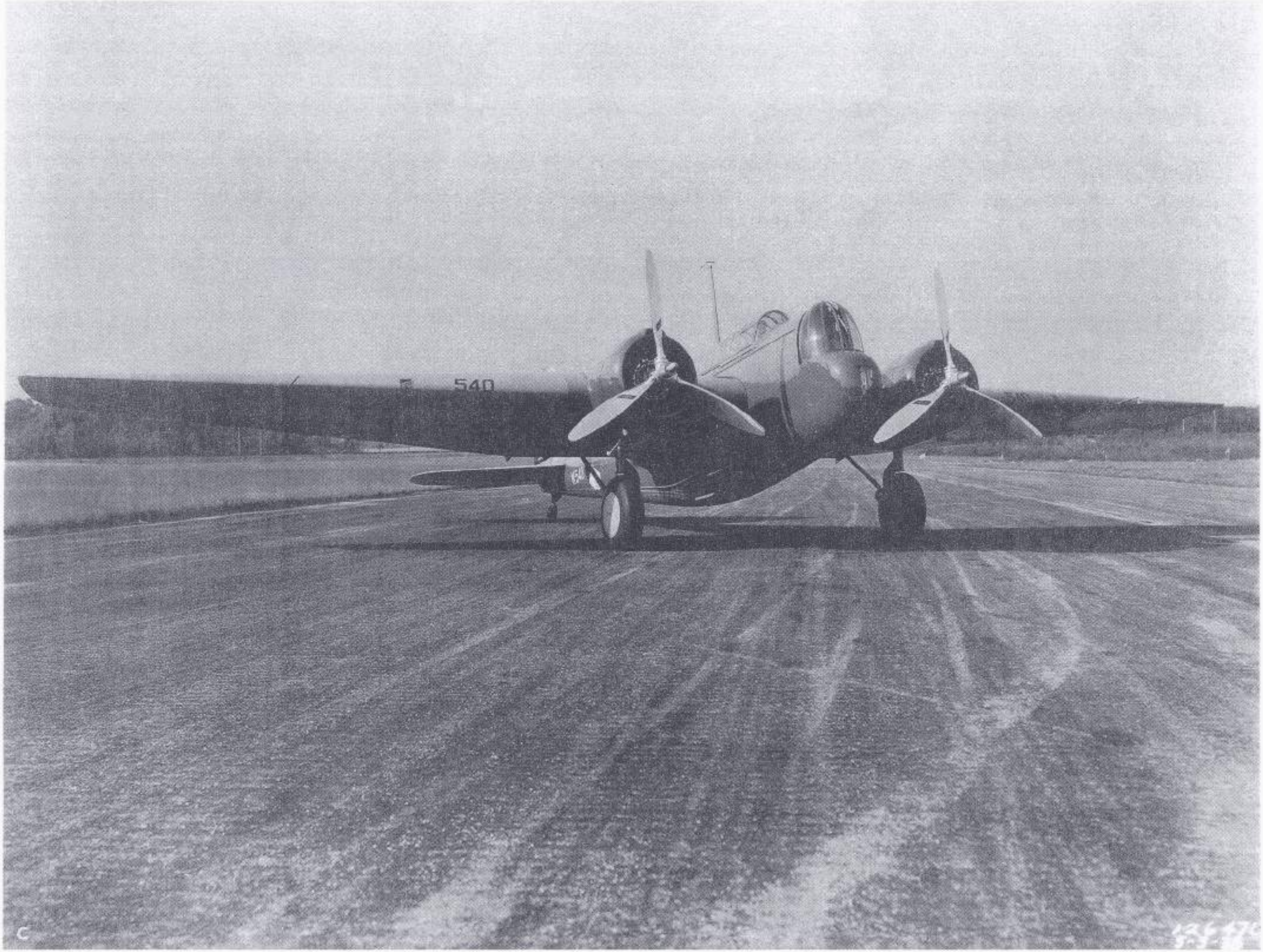


FIGURE 2 AIRPLANE - THREE QUARTER FRONT VIEW

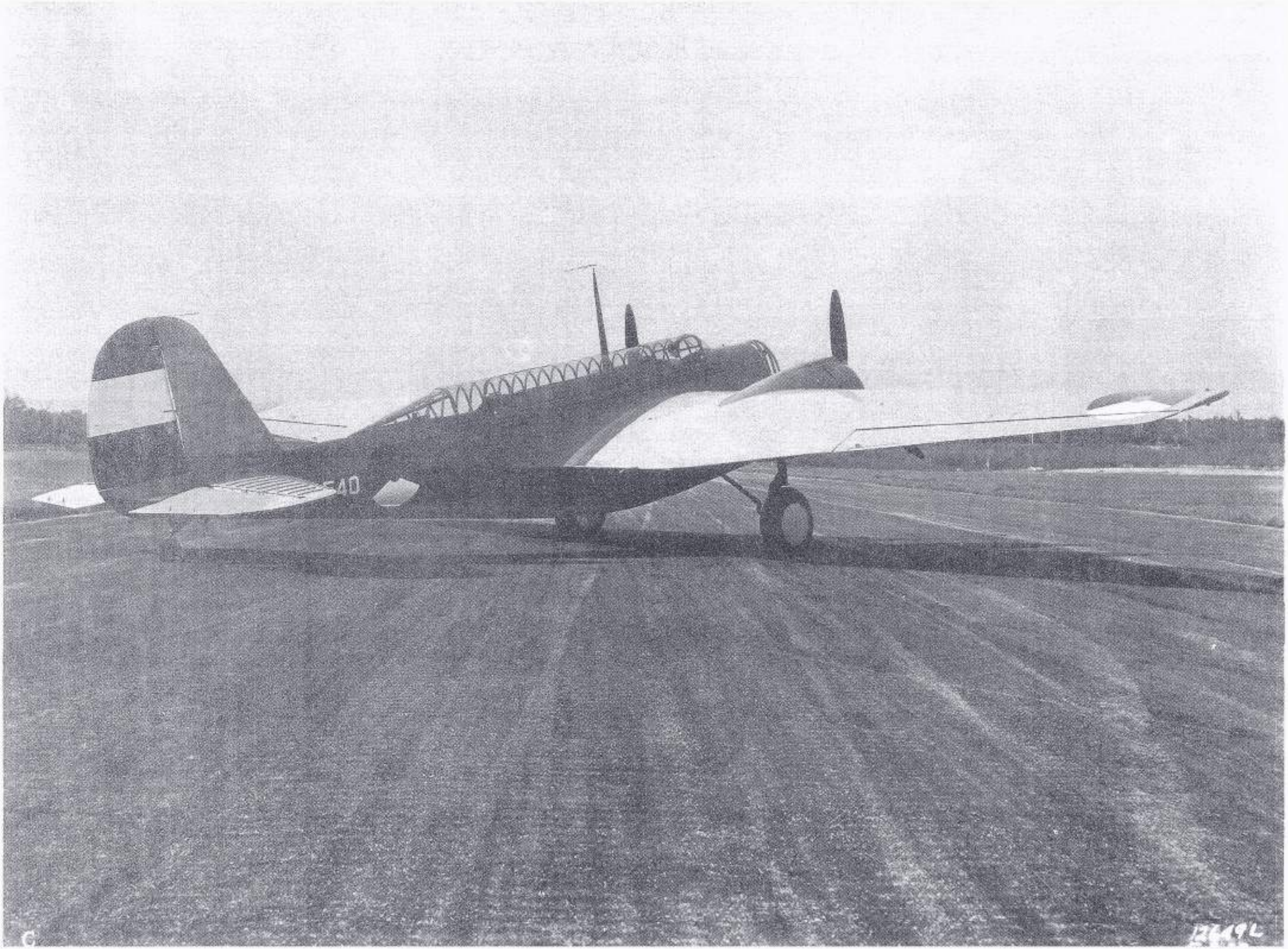


FIGURE 2A AIRPLANE - THREE QUARTER REAR VIEW

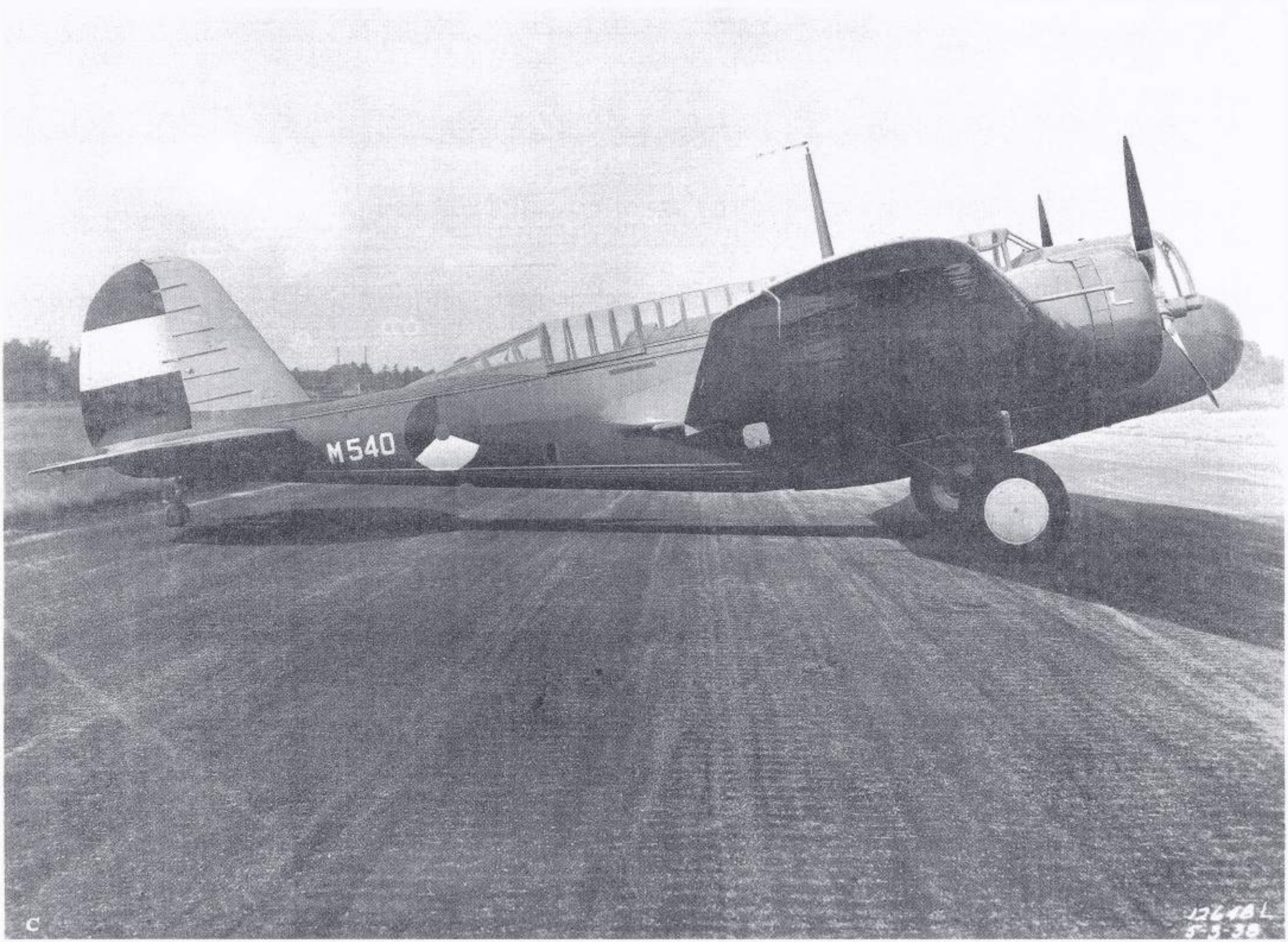


FIGURE 3 AIRPLANE - SIDE VIEW

Section II

Description

General Dimensions

Overall Span	70 Ft. $10\frac{1}{4}$ in. (21.6 m.)
Overall Length	44 Ft. $2\frac{1}{2}$ in. (13.47 m.)
Overall Height, thrust line level (to top of Rudder)	16 Ft. 9 in. (5.03 m.)
Overall Height, at rest (top of windshield)	11 Ft. 4 in. (3.45 m.)
Overall Height at rest including radio mast	14 Ft. 7 in. (4.44 m.)
Height, propeller hub, thrust line level	6 Ft. 9-9/32 in. (2.06 m.)
Fuselage clearance, propeller tips	0 Ft. 7 in. (.18 m.)

Tail Wheel

Size of tire	$13\frac{1}{4}$ In. Streamline (33.6 cm.)

Landing Gear

Tread	16 Ft. 0 in. (4.88 m.)
Axle centerline aft of leading edge	26-3/4 In. (.68 m.)
Size of tire	45 In. Streamline (114.3 m.)

Wings

Airfoil Section		Gottingen 398 Modified
Total area including ailerons and section within fuselage		682 Sq. Ft. (63.4 sq. m.)
Chord	root	150 In. (381 cm.)
	tip	54 In. (137 cm.)
Dihedral of upper surface (measured at 30% of chord from leading edge)		
Center Panel		0°
Outer Panel		1°
Incidence, theoretical chord line		0°
Angle of Sweepback-Outer Wings		14° - 10'

Aileron

Area to hinge Centerline of each aileron	20.94 Sq. Ft. (1.94 sq. m.)
Area of balance of each aileron	5.06 Sq. Ft. (.47 sq. m.)
Area of both ailerons, including tabs	52.02 Sq. Ft. (4.84 sq. m.)
Tabs	
Area, each, aft of hinge	.43 Sq. Ft. (.04 sq. m.)

Horizontal Stabilizer (Fixed)

Overall Span	20 Ft. 2 in. (6.13 m.)
Total area, to leading edge of elevator and including Fuselage	57.76 Sq. Ft. (5.21 sq. m.)
Incidence	Negative $1\frac{1}{2}^{\circ}$

Elevators

Area, both elevators, to hinge center-line, including tabs	48.78 Sq. Ft. (4.53 sq. m.)
Area of Balance, total	8.58 Sq. Ft. (.80 sq. m.)
Area, total, including tabs	57.36 Sq. Ft. (5.32 sq. m.)
Area, four tabs	3.62 Sq. Ft. (.34 sq. m.)

Vertical Stabilizer

Area	20.51 Sq. Ft. (1.90 sq. m.)

Rudder

Area to hinge centerline including tabs	18.45 Sq. Ft. (1.71 sq. m.)
Area of balance	4.50 Sq. Ft. (.42 sq. m.)
Area, total, (including tab.)	22.95 Sq. Ft. (2.13 sq. m.)
Area, Tab	1.34 Sq. Ft. (.12 sq. m.)

Weights	Overload Pounds	Overload Kilograms	Normal Useful Load Pounds	Normal Useful Load Kilograms
Weight Empty			10003	4537.3
Crew				
4 at 200 pounds (90.7 kg.)			800	362.9
Fuel				
Main Tanks 113 Gals per tank (428 liters) including reserve of 40 gals. (151 liters)			1356	615.1
Auxiliary Tanks 290 gals. (1097 liters)	1740	78.9		
Bomb Bay Fuel (250 gal.)(946 liters)	1500	680		
Oil				
Normal Load 21 gals. (79 liters)			157.5	71
Auxiliary 48 gals. (182 liters)	360	163.3		
Armament				
Installation of three flexible guns and 1500 rounds of Ammunition			272.7	124
Bombs 2-1100 lb. (500 kg.) incl. shackles			2265.4	1027.6
or 3-600 lb. (270 kg.) incl. shackles			1882.2	853.7
or 5-300 lb. (135 kg.) incl. shackles			1438.5	652.5
or 9-100 lb. (45 kg.) incl. shackles			1104.3	500.9
Bomb Racks and Controls (Internal)			129.5	58.7
Bomb Sight and Mount (Provision only)			16.4	7.4
Equipment				
Communication				
Radio and Wiring			219.0	99.3
Antenna			9.5	4.3
Interphone			12.5	5.7
Oxygen Equipment	68.5	31.1		
Signal Equipment (Pyrotechnics)			53.0	24.0
Miscellaneous			36.5	16.6
Special Equipment				
Life Raft	59.0	26.8		
Automatic Pilot	83	38		
Exhaust Gas Analyzers	21	9.5		
D3 Refueling Pump	11.6	5.3		
Non-Removable parts of Bomb Bay Fuel Tank	8.0	3.6		
Supercharger Pressure Regulator	18.3	8.3		
External Bomb Rack Controls	24.7	11.2		
Engine Synchroscope	1.4	.6		
Fuel Pressure Warning Unit	2.0	.9		
Loading				
Normal Military Useful Load			5328.0	2416.7
Total Weight Fully Loaded			15331.0	6954.0
Wing Loading Normal Load	22.48 lbs./sq.ft.		109.74 kg./sq.m.	
Power Loading Normal Load	9.02 lbs./h.p.		4.09 kg./h.p.	

The weights given in the normal weight column represent the usual military load. Special loads may be figured for any permissible combination from the weights given in the overload weight column. Special instructions for operating the airplane with gorss weight are contained in Section II-A.

Section II-A

Special Piloting Instructions

A. General Notes

Although the following instructions pertaining to the engines will not be found to conform strictly with those given in the general handbook issued by the Wright Aeronautical Corporation, those shown here are best suited to this particular model of engine as installed in this airplane. These special instructions have been approved by the Wright Aeronautical Corporation.

This section of the Maintenance Manual is included in order that station crew chiefs and mechanics may familiarize themselves with the operating requirements of the airplane and thereby acquire a more thorough understanding of the proper functioning of certain accessory items. A cross reference is made to several Sections and Paragraphs of the Manual wherein a more detailed description of the subject data is to be found.

A duplication of this Section is printed and bound separately under the title "Pilot's Manual", copies of which are furnished the users of these airplanes.

This airplane is equipped with the latest available types of accessories and equipment to increase its performance and efficiency of operation. It is, therefore, most important that pilots thoroughly familiarize themselves with the principles of operation and with the manipulation of these accessories in order that the full capabilities of the airplane may be utilized. Particular attention must be given to the correct cruising settings of throttles and supercharger controls (controlling manifold pressure), constant speed propellers (controlling engine speed), and mixture controls as indicated by the Cambridge Exhaust Gas Analyzer to attain optimum cruising range and efficiency.

Figures 4, 4A and 5, provide a ready means for the users of this airplane to familiarize themselves with the arrangement of all the pilot's instruments. The pilot should make a thorough study of the Figures and the following pages of these "Pilot's Instructions" prior to his first flight in the airplane. This should be done both away from the airplane and while sitting in the cockpit where the operation of certain items may be studied. Particular attention should be paid to the Warning Notes contained throughout these instructions.

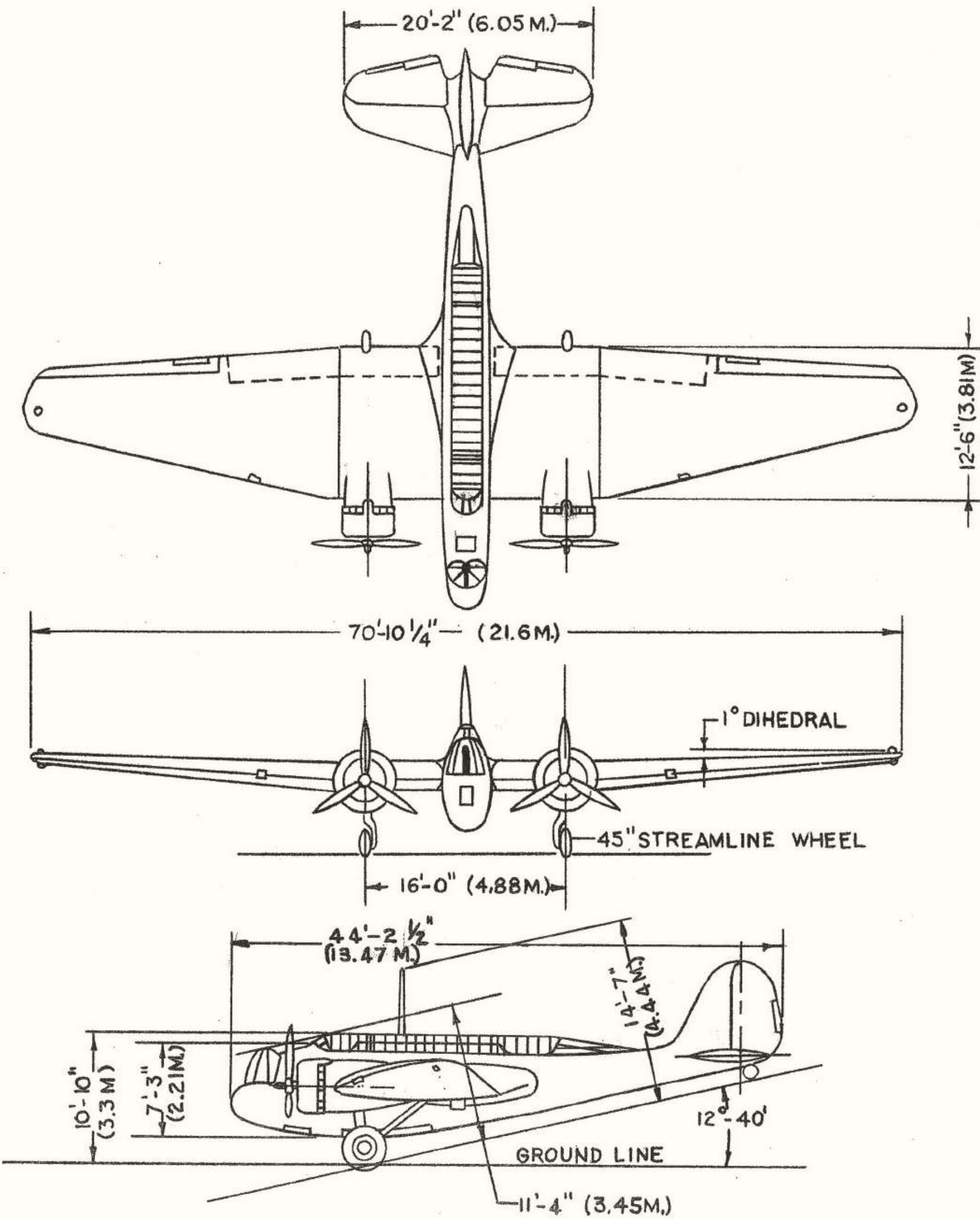


FIGURE 3A AIRPLANE - 3 VIEW DRAWING MODEL - 139-W

1. Power Plant Specifications (Wright "Cyclone" GR-1820-G5; Spec. 286-Q)

(a) Engine Details

Compression Ratio	6.45:1
Supercharger Gear Ratio	7.14:1 and 10:1
Propeller Gear Ratio	16:11
Rotation of Prop. Shaft (from rear end)	Clockwise
Diameter of Propeller	11 Ft. 6 in. (3.51 m.)
Propeller	Curtiss-Wright Corp.
Type-3 blade, 20° Constant Speed, Feathering, Electric control.	(Propeller Division)
Blade Setting	Low pitch 20° (at 42 in. Sta.) High pitch 40°(at 42 in. Sta.)
*Fuel, Grade Required	87 Octane (W.A.C. Spec. 5803)
*Oil, Grade Required	120 (W.A.C. Spec. 5817-A)

(b) Engine Ratings

(Subject to ±2½% variation)	Brake Horse-Power	Crank-Shaft RPM.	Alt. Ft.)	Manifold Pressure (In.Hg.)	Manifold Pressure (Cm.Hg.)	Super Gear Ratio
Maximum for Take-Off	950	2200	S.L.	39.5	100.33	7.14
Maximum for Protracted Periods	850	2100	S.L.	35.7	90.67	7.14
Maximum for Protracted Periods (Low Blower)	850	2100	6000	34.0	86.36	7.14
Maximum for Protracted Periods (High Blower)	750	2100	15200	33.5	85.09	10
Cruising Limits (Max.)	600	1900	Any			-
Recommended for Cruising	500	1850	Any	-	-	-

For FUEL, OIL, and CYLINDER HEAD TEMPERATURES see details in paragraphs E (Warming Up), F (Take-Off), and G (Climb).

(c) Fuel consumption data are given in Graphs 1 to 8 at the end of this section.

(d) Oil Consumption (both engines)

At 2100 R.P.M.	6.0 Gal./Hr. (22.8 Li./Hr.)
At 1850 R.P.M.	3.0 Gal./Hr. (11.4 Li./Hr.)

Note: The oil requirements for Wright Cyclone "G" series engines are covered in W.A.C. Bulletin 308. This bulletin will be kept up to date by the Wright Aeronautical Corp. and will include any oils in addition to those listed in the Maintenance Manual as they are approved in accordance with W.A.C. Specification 5817-A. It is desired that the engine operators keep in touch with the Wright Aero. Corp. relative to additional oils that may be available in the operator's territory.

For oils already approved per Wright Aeronautical Corporation Bulletin No. 308, see Appendix IV of Maintenance Manual.

Note: Except in abnormally cold or hot climates, Grade 120 S.A.E. oil, W.A.C. Spec. 5817-A is recommended for year around use.

NOTE: Gasoline having a lower than 87 octane rating should not be used except in emergency. If used, full throttle and high supercharger ratio operation should be avoided.

*All referenced specifications will be found under a separate cover titled U.S. Government Specifications, covering lubricants and compounds as listed in the Maintenance Manual.

Explanation Note

The following performance data is based on the gross weights listed in the "Detail Specifications" and in the Acceptance Demonstration of Performance for the 139-WH3 airplane. These weights do not include the Special Equipment items listed under Detail Actual Weights in paragraph A-3(a-1). Therefore, the weights for the performances listed below do not agree with the actual weights as determined by weighing the airplane with all special equipment included.

2. Performance Summary

(a) Normal Gross Weight (Without Special Equipment). . .	6982.6 kg.	(15331 lbs.)
Engine Critical Altitude	4632.7 m.	(15200 ft.)
High Speed at Engine Critical Altitude(750 BHP/Eng.)	387 km./hr.	(240.5 mph.)
High Speed at Sea Level (850 BHP/Engine)	348 km./hr.	(216 mph.)
High Speed in Level Flight (750 BHP/Engine).	396 km./hr.	(246 mph.)
Altitude for High Speed in Level Flight	5364.1 m.	(17600 ft.)
Minimum Time to Climb to 3,048 meters(10,000 ft.). .	5.9 min.	--------------
Climb in First Ten Minutes	4571.8 m.	(15000 ft.)
Maximum Rate of Climb at Sea Level	9.39 m/sec.	(1850 ft./min.)
Maximum Rate of Climb at First Engine Critical Alt..	8.78 m/sec.	(1730 ft./min.)
Best Climbing Speed at Sea Level (True).	206 km./hr.	(128 mph.)
Best Climbing Speed at Critical Altitude (True). . .	224 km./hr.	(139 mph.)
Service Ceiling (2 Engines)(Low Blower).	8702.4 m.	(28200 ft.)
Absolute Ceiling (2 Engines)(Low Blower)..	9196.2 m.	(29800 ft.)
Absolute Ceiling (1 Engine).	4166.0 m.	(13500 ft.)
Takeoff Ground Run (950 BHP/Engine).	220 m.	(721 ft.)
*Stalling Speed with High Lift Devices.	104.5 km./hr.	(65 mph.)

*With Normal Gross Weight minus bombs and ½ fuel and oil. Gross Weight = 5649 kg. (12456 lbs.)

RANGE AND ENDURANCE**

	Metric	English	Metric	English	Metric	English
Gross Weight - kg. (lbs.)	6952.6	15331	7838	17284	8273.6	18244
Fuel Carried - liters (gals.)	854	226	1953	516	2899	766
Maximum Range at 3505 meters (11500 ft.) - km. (mi.)	1307	812	2818	1758	4055	2520
Maximum Endurance - hrs.	6.06		12.65		18.52	
Average speed - km./hr (mph.)	216	134	224	139	219	136
Range at Operating Speed at 3505 m. (11500 ft.)-km. (miles)	1188	738	2607	1620	3860	2400
Endurance at Operating Speed-hrs.	4.35		9.54		15.	
Operating Speed-km./hr. (mph.) (Emergency Only)	274	170	274	170	258	160
Range at High Speed at 3505 m. (11500 ft.)-km. (mi.)	557	346	1258	782	1770	1100
Endurance at High Speed-hrs.	1.54		3.48		5.18	
Average High Speed-km./hr.(mph.)	362	224.8	360	224.2	360	224

**Conservatively estimated with weight of bombs included for complete flight. No allowance is made for fuel required to climb to 3505 meters (11500 feet). Ranges and endurances correspond to the handbook curves which are based on flight test performance and engine specification fuel consumptions.

3. Weight Data

The following weight data is provided to ascertain the load condition for any type of mission. Before flight operations are started, a comparison of the airplane with these data is very important.

(a) Detail Actual Weights

(1) Normal Useful Load (with Special Equipment)	5625.5 lbs.	(2551.7 kg.)
Crew (4 at 200 lbs. each)	800 lbs.	(363 kg.)
Fuel (226 gal. at 6 lbs./gal.)	1356 lbs.	(613 kg.)
Oil (21 gal. at 7.5 lbs./gal.)	157.5 lbs.	(71 kg.)
Armament- -	2684 lbs.	(1217 kg.)
Flexible Guns Complete (3)	272.7 lbs.	(124 kg.)
Bomb Installation	2411.3 lbs.	(1094 kg.)
Equipment -	330.5 lbs.	(150 kg.)
Radio and Communicating	241 lbs.	(109 kg.)
Flares and Signals (Pyrotechnic)	53 lbs.	(24 kg.)
Miscellaneous	36.5 lbs.	(17 kg.)
Special Equipment (not included in Detail Specs.) - - -	297.5 lbs.	(135 kg.)
Automatic Pilot	83 lbs.	(38 kg.)
Exhuast Gas Analyzer	21.0 lbs.	(9.5 kg.)
D-3 Refueling Pump	11.6 lbs.	(5.3 kg.)
Life Raft (Inflatex)	59 lbs.	(26.8 kg.)
Non-Removable parts of Bomb Bay Fuel Tank	8 lbs.	(3.6 kg.)
Supercharger Pressure Regulator	18.3 lbs.	(8.3 kg.)
Oxygen Equipment	68.5 lbs.	(31.1 kg.)
External Bomb Rack Controls	24.7 lbs.	(11.2 kg.)
Engine Synchroscope	1.4 lbs.	(.6 kg.)
Fuel Pressure Warning Unit	2.0 lbs.	(.9 kg.)
(2) Overload (Increased Range with Bombs) - - - - - - - -	7515.5 lbs.	(3409 kg.)
Crew (4 at 200 lbs. each)	800 lbs.	(363 kg.)
Fuel (516 gal. at 6 lbs./gal.)	3096 lbs.	(1404.3 kg.)
Oil (41 gal. at 7.5 lbs./gal.)	307.5 lbs.	(139.5 kg.)
Armament	2684 lbs.	(1217 kg.)
Equipment (Includes Special Equipment)	628.0 lbs.	(285 kg.)
(3) Overload (Maximum Increased Range with Bombs) - - - - -	8411.6 lbs.	(3815.4 kg.)
Crew (4 at 200 lbs. each)	800 lbs.	(363 kg.)
Total Fuel (766 gal. at 6 lbs./gal.)	4596 lbs.	(2085 kg.)
Bomb Bay Fuel Tank (250 gal.)--without fuel	135 lbs.	(61.2 kg.)
Oil (48 gal. at 7.5 lbs./gal.)	360 lbs.	(163 kg.)
Bomb Installation (incl. External Racks)	369.9 lbs.	(167.8 kg.)
Equipment (Includes Special Equipment)	628.0 lbs.	(285 kg.)
Armament (3 Flexible Guns Complete)	272.7 lbs.	(124 kg.)
Bombs (2-625 lbs.) on External Racks	1250.0 lbs.	(567 kg.)
(4) Overload (Maximum Armament)- - - - - - - - - - - - - - -	8777.0 lbs.	(3981.2 kg.)
Crew (4 at 200 lbs. each)	800 lbs.	(362.9 kg.)
Total Fuel (326 gal. in Wing Tanks)	1956.0 lbs.	(887.2 kg.)
Oil (30 gal. at 7.5 lbs./gal.)	225.0 lbs.	(102.1 kg.)
Armament (3 Flexible Guns)	272.7 lbs.	(124.0 kg.)
Internal Bomb Installation and 2-1100 lb. Bombs	2411.3 lbs.	(1093.7 kg.)
External Bomb Installation and 2-1100 lb. Bombs	2484.0 lbs.	(1126.7 kg.)
Equipment (incl. Special Equipment)	628.0 lbs.	(285.0 kg.)

(b) Gross Weights

(1) Normal Gross Weight (with Special Equipment)	15628.5 lbs.	(7088.9 kg.)
(2) Overload Gross Weight (Increased Range)	17518.5 lbs.	(7946.2 kg.)
(3) Overload Gross Weight (Maximum Increased Range)	18414.6 lbs.	(8352.7 kg.)
(4) Overload Gross Weight (Maximum Armament)	18780.0 lbs.	(8518.4 kg.)
(5) Weight Empty	10003.0 lbs.	(4537.3 kg.)

(c) Load Factors

The airplane structure is designed for a gross weight of 15,400 lbs. Positive load factors have been maintained with the above gross weight for all "U.S. Air Corps" requirements, including gust conditions combined with diving speeds up to and including 260 m.p.h. true speed. In addition to this, the airplane shall be designed for a steady dive speed of 300 mph with a load factor of 3.0 including the standard material factor of safety.

Design Load Factors based on the Normal Gross Weight of 15400 lbs. (6985 kg.)

Positive High Angle- -	5.5
Positive Low Angle -	5.5
Negative Low Angle -	3.0
Negative High Angle- -	3.0
Factor for Steady Dive at the Maximum allowed Diving Speed of 300 mph. (482 km./hr.)- -	3.0
Landing based on 13140 lbs. (5960 kg.) - - - - - - - - - - - - - - - - - - (Normal Gross Weight less bombs)	5.0

Design Load Factors based on the Overload Gross Weight of 18596 lbs. (8435 kg.)

Positive High Angle- -	4.5
Positive Low Angle -	4.5
Negative Low Angle -	2.5
Negative High Angle- -	2.5
Landing based on 14076 lbs. (6384.8 kg.) - - - - - - - - - - - - - - - - - (Max. Overload Weight less bombs)	4.0

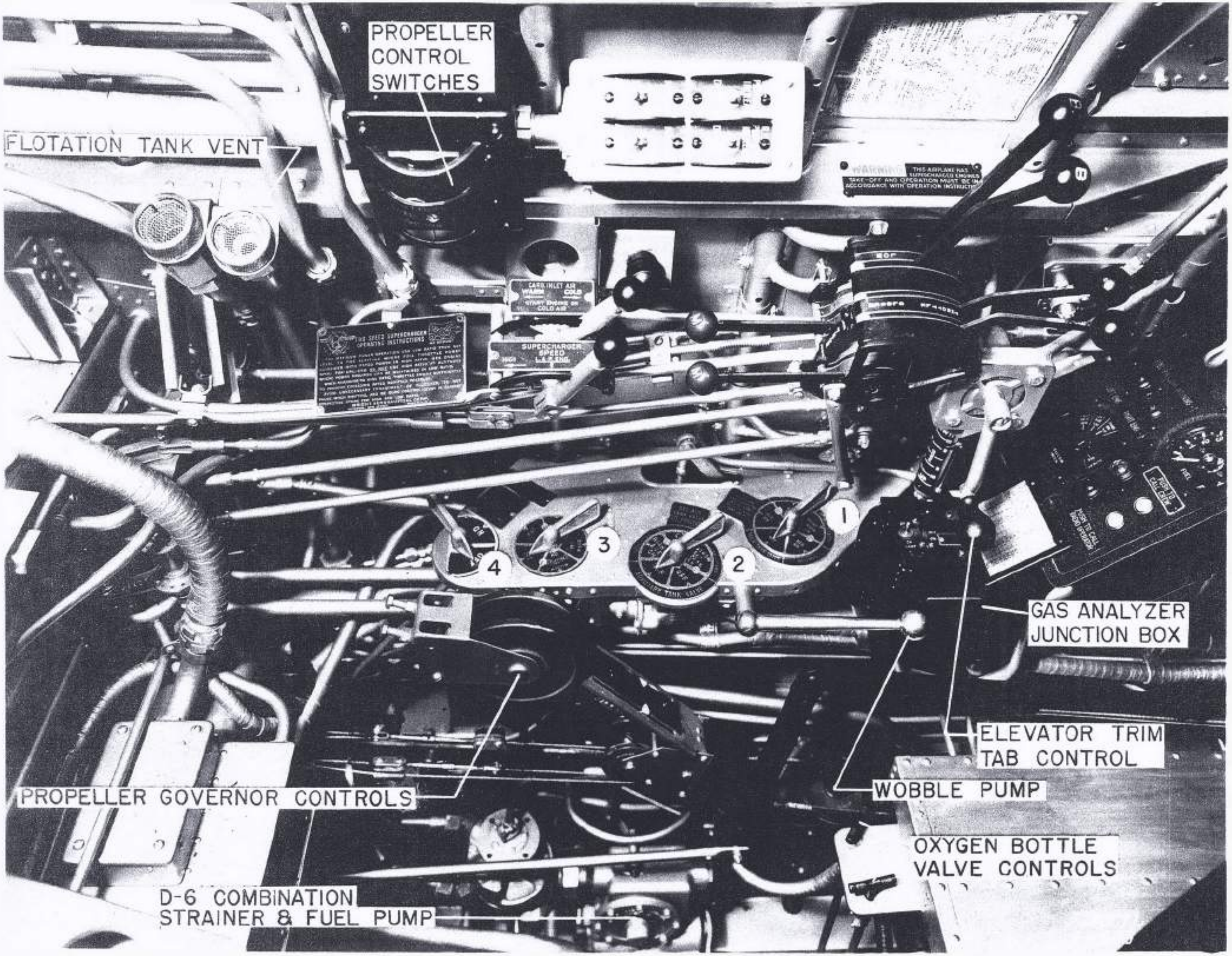


FIGURE 4 INSTRUCTIONS AND CONTROLS IN PILOT'S COCKPIT - LEFT SIDE

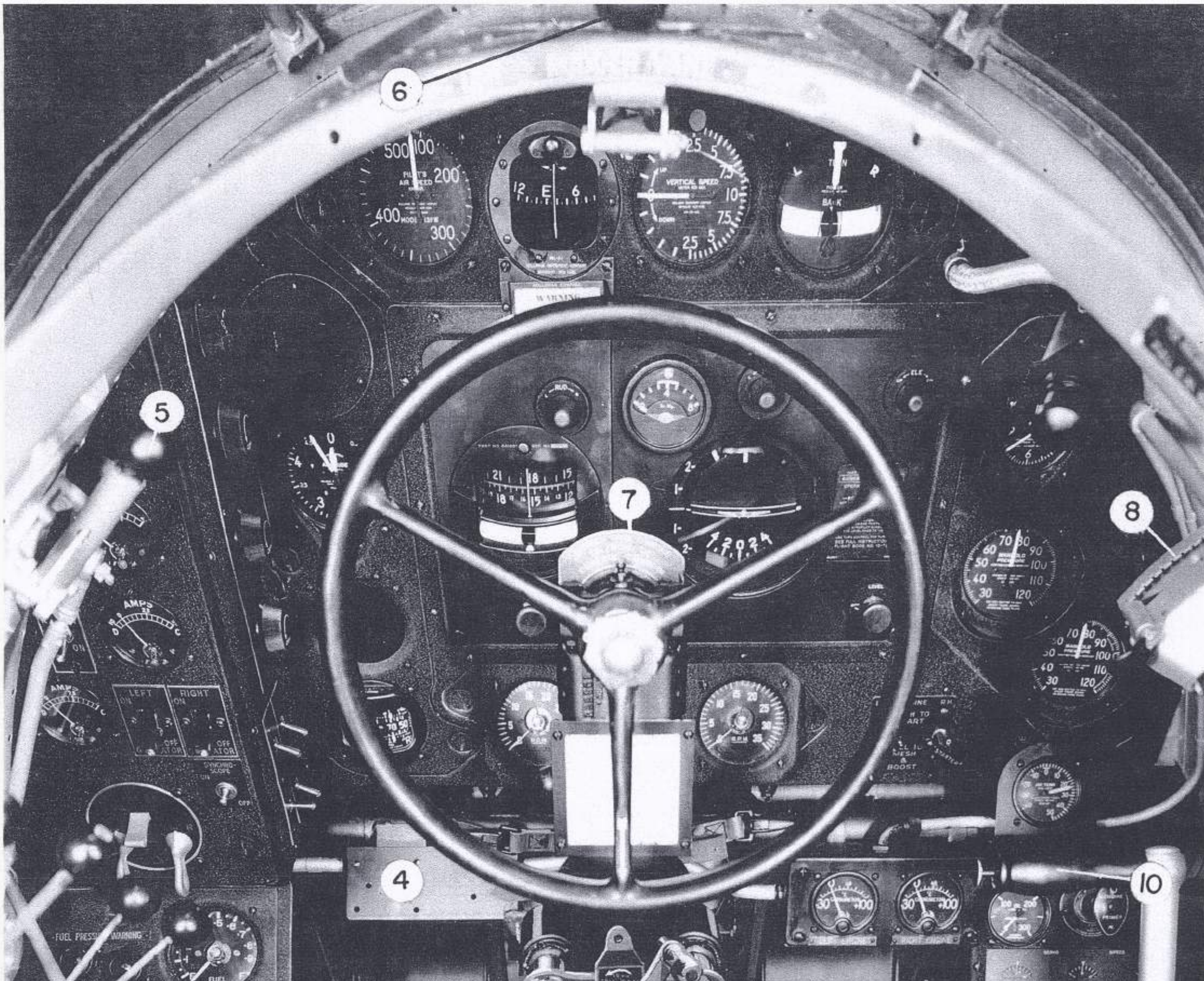


FIGURE 4A INSTRUMENTS AND CONTROLS IN PILOT'S COCKPIT - FRONT VIEW C

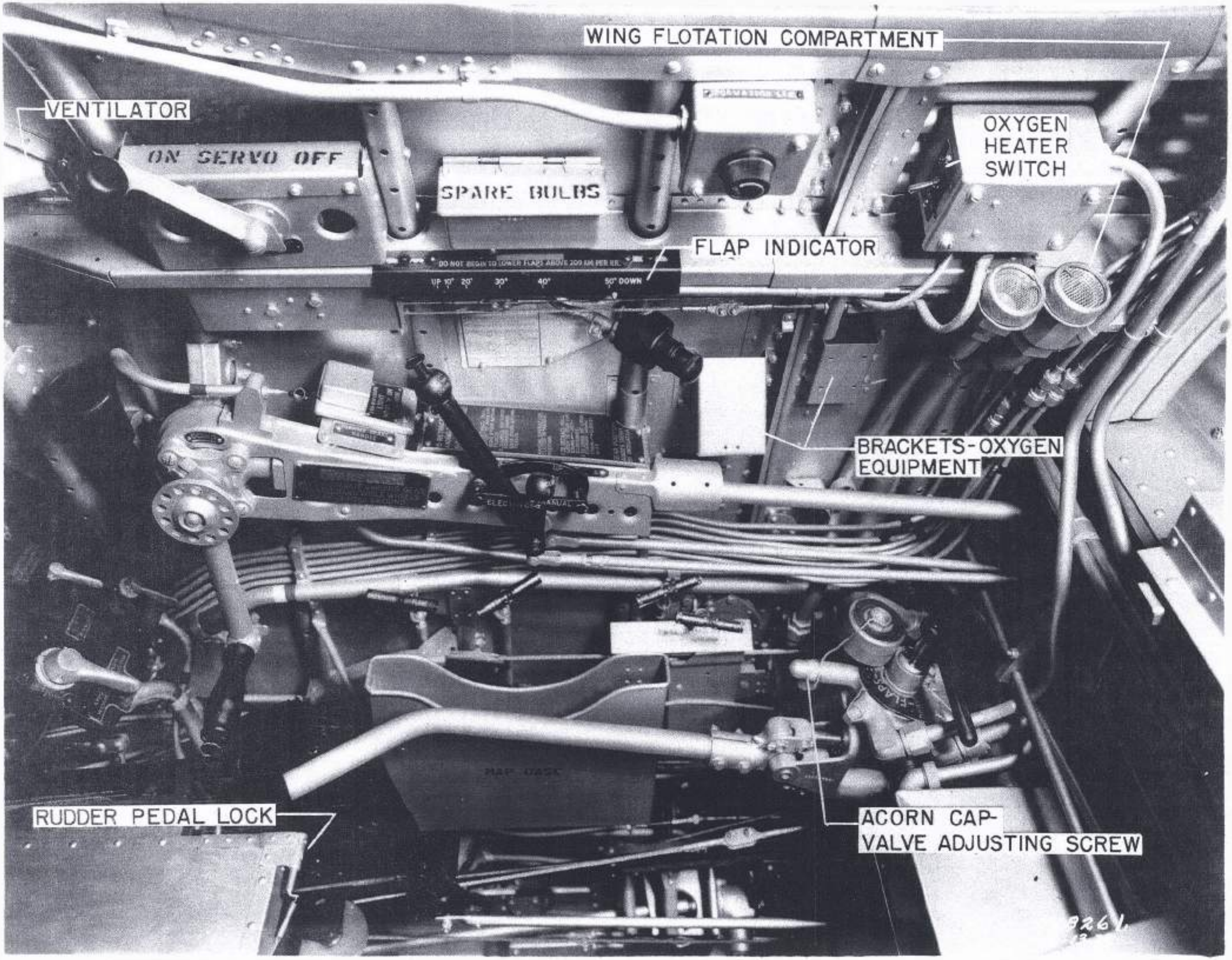


FIGURE 5 INSTRUMENTS AND CONTROLS IN PILOT'S COCKPIT - RIGHT SIDE

PILOT'S COCKPIT

B. LOCATION OF CONTROLS

1. POWER PLANT CONTROLS in the pilot's cockpit consist of the following:

(a) Engine Control Unit: This unit is a modified B-6 type having two fuel throttles and two mixture control levers, and incorporating two engine supercharger regulator control levers. The unit is located on the left side of the fuselage with all the levers within easy reach of the pilot.

(1) Throttle Control Levers are located on top of the unit adjacent to the pilot.

(2) Mixture Control Levers are located on the rear side of the unit nearest the pilot, and have red handles.

(3) Supercharger Regulator Control Levers are located on top of the unit adjacent to the fuselage, and are longer than the throttle levers.

(4) The use of these controls is described in following paragraphs dealing with the operation of the engines.

(b) The Supercharger Speed Control Lever is located just aft of the engine control unit.

(c) Carburetor Air-Heater Control: The control handle for the carburetor air heater is located on the left side of the fuselage aft of the engine control unit adjacent to the supercharger speed control. This control is of the fixed position type operated by pressing down on the handle knob to relieve the ratchet latch.

(d) Clean-out Valve - Manifold Pressure Line: This valve control lever is located on the lower right hand auxiliary instrument panel. It is used to remove the condensate from the manifold pressure lines, and can be used when the engines are running at idling speed. Twenty seconds is sufficient time to clean out the lines.

(e) Engine Cowling Flap Controls: The flaps are operated by a crank assembly installed on the control column. Two locking control wheels are included by means of which either engine cowl flap may be operated independently. Turning the crank counter-clockwise opens the flaps. The handle is spring loaded to provide a means of locking the controls in a fixed position. The handle must be held back while turning.

2. FUEL CONTROLS

(a) Valves

(1) Four fuel valve control levers are located on a horizontal bracket at the left side of the cockpit. The front lever (No. 1) controls the main tank valve; No. 2 lever controls the auxiliary tank valve. These two valves are located in the bomb bay. The No. 3 lever controls the engine selector valve; and the rear (No. 4) lever controls the cross feed valve. These two valves are located below the pilot's seat on the left side of the fuselage.

(b (2) The reserve fuel supply of 40 gallons (151 liters) is contained in the left front (main) tank and is selected by the No. 1 lever.

(3) The No. 2 lever is moved to either "Left Aux. On" or "Right Aux. On" or to the Bomb Bay Tank Sector, if that tank has been installed. IMPORTANT: The main valve lever (No. 1) must be first set at "Aux. On" before fuel can be taken from any auxiliary tank.

(4) The engine supply valve No. 3 is used to distribute the fuel to either or both engines as desired. Normally this valve will be set at "Both On." In case of fire in either nacelle, the fuel to that engine should be shut off.

(5) The rear(No. 4)valve is used to provide fuel to both engines from the operating pump in case one pump should fail. For take-off, climb and while landing,this valve must be in the ON position. When checking fuel pumps individually on the ground or in the air, this valve must be in the OFF position otherwise accurate fuel pressure readings for each engine cannot be obtained.

(b) Wobble Pump: A hand pump is located on the bracket adjacent to the fuel valves. See paragraph D, "Starting Engines", for use of this pump.

(c) Engine Primer: A dual engine primer is located at the top of the auxiliary control panel below the landing gear handcrank. See Notes on engine priming, paragraph D-11, Starting Engines.

(d) Fuel Quantity Indicator: A dial type gauge is located on the auxiliary instrument panel at the left side of the cockpit together with a selector switch which must be turned to the tank from which fuel is being drawn to register fuel quantity in that tank. A fuel quantity reading for any one of the four wing tanks or the bomb bay tank is shown on the gauge located above the switch. The instrument readings must be converted by means of the conversion chart located adjacent to the gauge.

3. ELECTRICAL CONTROLS

(a) Batteries. The battery circuits can be opened by means of a modified Type AN-4010 control handle which is located immediately forward of the throttle. It is important that this handle be moved to the "Off" position when the airplane is left standing unattended.

(b) Magneto Switches: Three switches are located on the vertical auxiliary instrument panel at the left side of the cockpit. The center lever operates the master cutout switch which opens the circuit to both magnetos simultaneously. This switch must be moved up before the magneto switches can be operated. See paragraph R for detail instructions on magneto checking.

(c) Starter Switches: Two Eclipse M-2609 starter switches are located on the lower right side of the main instrument panel. These switches are operated by pushing in on the handle to close the circuit to the starter relay and thence to the starter. Maximum speed of the starter motor is obtained in approximately 20 seconds. The handle is then pulled outward from the panel causing current to flow to the meshing solenoids on the starter clutch engaging the starter with the engine.

Warning: Start only one engine at a time. If both switches are operated at the same time, the circuits will be overloaded and the 30 ampere fuse in the system may be blown out. When starting engines that have been idle overnight or at any time during extreme cold weather, the propellers should be turned over at least four revolutions by hand in the direction of normal rotation before engaging the starter.

In extreme cold weather when the airplane is left outdoors, it is advisable to use the handcrank or a portable electric starter attached to the handcrank shaft for turning up the inertia gearing. This will insure against imposing too great a load on the battery. See paragraph D, Starting Engines.

(d) Propeller Controls

(1) Switches: The pilot's electric control system for the propellers consists of a group of six switches located at the left side of the cockpit. This group includes two toggle type Control Switches equipped with shields to prevent accidental operation. These switches are used to shut off the power supply to the propeller circuits when the airplane is not in use, thereby preventing a steady drain on the batteries. Two Constant Speed-Manual Control Selector Switches of the two-position toggle type They are used to switch the source of power supply into either the constant speed control circuit or the manual control circuit. Two Manual Control Switches of the momentary contact snap type having two poles and an intermediate "Off" position. These switches must be held in either the "pitch increase" or "pitch decrease" contact position to operate. The propellers are "feathered" with these switches.

(2) Governor Controls: Two micarta hand-wheels located adjacent to the pilot's seat at the left side of the airplane are used to change the setting of the constant speed governors.

(3) Operation of the propellers in flight is described in paragraph P, Propeller Operation.

(e) Generator Switches: Two toggle switches are located on the vertical auxiliary instrument panel above the magneto switches. These switches are left "ON" while the engines are running to show the rate of charge or discharge on the adjacent ammeters. In case of an overcharging generator caused by malfunction of the voltage regulator, the circuit to the generator can be opened with the corresponding switch to prevent burning out the generator.

(f) Voltmeter Switch is a two position toggle switch located above the generator switches and is used to select the generator from which the voltage is to be read. See paragraph T for details on Voltmeter Checking.

(g) Light Switches and Rheostats: The landing lights and running lights are operated by a group of toggle switches located on the vertical panel at the left side of the main instrument panel. These switches are identified by their name plates. The intensity of the instrument panel lights may be varied by rheostats located on the switch panel.

Formation flying lights are operated and intensified by a rheostat located on the right side of the cockpit.

(h) Pitot Static Head Switch: Is a two position switch located below the landing light switches, and used to prevent ice formation in the head. This switch should be turned to "ON" when icing conditions are prevalent.

4. TRIM TAB CONTROLS - FLIGHT CONTROL SURFACES

(a) The elevator trim tab hand crank located on the left side of the cockpit is rotated clockwise for "NOSE DOWN". For take-off in normal conditions this tab is set at 0°, and for landing, it is set at full "NOSE UP" position.

(b) The aileron trim tab control is located on the forward side of the control column and is moved to the "Left" to compensate for a right wing heavy condition and vice versa.

(c) The rudder trim tab control is located directly before the pilot on the top of the fuselage within the windshield and is moved to the "Left" to compensate for a yawing condition toward the right.

(d) Wing Flap Controls

The wing flaps are operated by means of a hand pump and direction control valve located at the right side of the pilot's seat. See paragraph J, Wing Flap Operation. A flap position indicator is provided on the longeron directly above the landing gear controls.

Restrictions on the use of these flaps are detailed in paragraph I of **these instructions.**

5. LANDING GEAR OPERATION

(a) The landing gear controls are located on the right side of the pilot's cockpit. It is suggested that all pilots familiarize themselves with the operation of the landing gear retracting mechanism before the first flight. This can readily be accomplished by hoisting or jacking up the airplane free of the ground.

(b) The landing gear is composed of two retractable main wheels and a non-retractable tail wheel. The main wheels are retractable both electrically and manually. Operation is by means of lever-type handles installed on quadrants at the pilot's right, and by an adjacent hand crank. The short handle operates the electrical-meshing clutch and cutout switch The long handle is for controlling movement of the gear and lifting the locks. A position indicator is provided on the bracket behind the control lever quadrant and a white signal light is installed on the bracket forward of the control quadrant to indicate when the landing gear is fully down. In addition to these indicators a warning vibrator is installed on the left rudder pedal to function when the throttle for either engine is closed before the landing gear is completely down. Should flight conditions require a throttle to be closed continuously, (such as the failure of one engine), the vibrator will continue to operate until the ignition switch for the failing engine is cut off and the throttle for that engine opened far enough to break the vibrator circuit. However, the vibrator will again operate when the other throttle is closed. See also paragraph P on operation of Curtiss Propellers.

(c) Directions for operating the landing gear are shown on the instruction plate adjacent to the lever control quadrant. They are repeated here for reference and study.

Electrical Operation of Landing Gear - Clutch in "Electric" position.

To Retract Pull latch rearward ("Up"). Gear stops automatically.
To Lower. Push latch forward ("Down"). Gear stops automatically.

Manual Operation of Landing Gear - Clutch in "Manual" position.

To Retract. Pull latch rearward ("Up"). Crank couter-clockwise.
To Lower. Push latch forward ("Down"). Crank clockwise.

Note: When the latch is operated, movement should be rapid and through the complete travel. Slow or partial movement may cause arcing of the master switch and eventually malfunctioning of the gear.

(d) Warning - Landing Gear Use (1) NEVER OPERATE THE ELECTRIC OR MANUAL RETRACTING CONTROLS WHILE THE AIRPLANE IS RESTING ON THE GROUND.

(2) Landing: The white light which indicates closing of the landing gear lock pins must be "ON" before landing. Should the light not appear, engage crank by depressing the thumb button and turn clockwise. A hard partial turn assures the lock engagement whether the light works or not.

(e) Brakes: The wheel brakes are of the internal expanding type, hydraulically operated by means of toe-controlled foot pedals. Due to the large brake-shoe area provided, it is not necessary to use the brakes very hard when they are properly adjusted. When parking in the open, the brakes may be locked by depressing both toe pedals equally and pulling on the parking brake handle which is located adjacent to the hand crank. To release parking brake, depress both toe pedals until both locking ratchets are released.

Note: Pilots of short stature are cautioned to adjust brake pedals to the rear-most position and check for full application of brakes before taking off.

6. EMERGENCY CONTROLS

(a) Flare Controls: Two type A-3 pull handles are provided on the right side of the cockpit below the landing gear control quadrant for releasing the parachute flares.

(b) Bomb and Tank Releases: Two Type A-3 emergency release handles are located on the right side of the fuselage forward of the wing flap valve control handle. These handles are used for emergency release of the bomb racks which will salvo all bombs carried on the racks, or drop the 250 gallon auxiliary fuel tank if it is installed, or open the dump valve of the 356 gallon tank if it is carried. The bomb bay doors open automatically at the same time.

Note: It is recommended that dumping fuel from the 356 gallon tank in flight be confined to emergency cases only. (Routine dumping tests can be made using water). In either case, the curtain provided must always be installed when the tank is used.

7. EQUIPMENT CONTROLS

(a) Automatic Pilot Controls

(1) A No. 6 Parker shut-off valve is provided in the oil line between the gyropilot and the oil sump to by-pass the oil back to the sump when the pilot is shut off while the engines are running. This valve is located on the lower right side of the auxiliary control panel below the landing gear hand crank.

(2) A lever control for by-passing oil around the servo unit when the autc matic pilot is not in operation but when the gyro instruments are in use is provided on a bracket located on top of the longeron above the landing gear hand crank.

(3) Three knobs for operating the speed control valves are located on the auxiliary control panel below the landing gear hand crank.

(4) A 3 way vacuum selector valve is located on the lower left side of the auxiliary control panel and is used to obtain vacuum from either the right or left engine individually or both together.

(5) Oil Pressure Gauge. This gauge is located on the auxiliary control panel and registers the oil pressure to the Automatic Pilot Servo Unit. It

is graduated from 0-300 lbs. per sq. in. Normal pressure should read approximately 100 lbs. per sq. in.(4.53 kg./sq.cm.).

(6) Suction Gauge. This gauge is located on the main panel with the Gyro Horizon and is used to check the amount of vacuum in the system. The desired vacuum for operating the Gyro instruments should be 4 inches (101.6 mm.) of mercury. It should not be less than 3 inches (76.2 mm.) or more than 5 inches (127 mm.).

(b) Fire Extinguisher: A one quart capacity Pyrene fire extinguisher is located on top of the fuselage in the rear section of the pilot's cockpit enclosure.

The installation of a pressure fire extinguisher system is optional with the users of the airplane. When installed, the valve for operating the left engine pressure system is located on the bottom of the auxiliary instrument panel adjacent to the fuel tank gauge selector switch. The valve for the right engine system is located below the landing gear control quadrant.

(c) Rudder Pedal Lock: The right hand rudder pedal can be locked in the extreme forward position by means of a bolt type latch mechanism located at the right rear edge of the floor installed forward of the control column.

(d) Pilot's Seat. The seat is adjustable up and down by means of a lever on the right side. Apply a slight pressure of the body to the seat when adjusting downward. The seat is hinged to permit the crew to change places. The latch is located on the bottom side near the front. Inadvertent release of the seat is prevented by a 1/32" galvanized iron safety wire around the handle and locking rod. The wire can be broken by a hard pull.

(e) Oxygen Apparatus: The pilot's oxygen regulator is located on the right side of the fuselage opposite the seat. In addition and near the pressure control valve, a switch is provided for energizing the circuit to the oxygen heater element installed below the control valve. Two tee handles are provided on the pilot's floor directly aft of the left rudder pedal for control of the supply cylinder valves. The supply hose is attached to a bayonet type base located near the center of the rudder support tube.

(f) Junction Box - Gas Analyzer: This unit is installed on the left side of the fuselage below the elevator trim tab control. Operation of this equipment is described in paragraph M of this Section.

C. Pre-Flight Check

After the airplane has been serviced and made ready for a flight, a careful check of the fuselage should be made to ascertain that no tools or small pieces of equipment are lying loose where they may jam the controls.

The pre-flight inspection procedure is detailed in Section XXIII of the Maintenance Handbook and will have been made before the airplane is turned over to the pilot.

In cold weather, the oil should be heated for starting and provision has been made in both oil tanks for a screw-in type electric immersion heater. The heater flanges are accessible through the wheel well. In cold weather it is also advisable to turn the engines over at first with the hand starter as a heavy engine, when cold, imposes too great a load on the starter and battery.

Before attempting to start the engines after they have been idle for a period (even over night), the propeller should be turned by hand for at least four revolutions in the direction of normal rotation. Should an abnormal effort be required, remove spark plugs from lower cylinders to determine if any liquid has collected there, as this may cause serious damage. During the rotation of the propeller, the dynamic damper in the engine falls against a retainer plate on the crankshaft when the counterweights are raised above the horizontal position. The noise of this fall is in some cases discernible but is a normal occurrence and should cause no apprehension.

Before starting the engines, the pilot should check the following items.

1. Check amounts of fuel and oil in each tank and also Automatic Pilot tank.

2. Have chocks placed in front of the landing wheels, or if no chocks are available, apply both brakes firmly and engage parking latches.

3. See that bomb bay doors and all other doors are closed and securely latched.

4. Set wing flap control valve to "Up" and operate the flap pump handle through a few strokes to insure that flaps are in the full "Up" position. Note flap position indicator.

5. Unlock flight controls and see that they are free to move through the full range of travel.

6. Place elevator, aileron, and rudder tab controls in neutral positions.

7. Check Automatic Pilot "Servo" controls to be sure that they are "OFF."

Important. The engines should not be started immediately after refueling if the tanks have been allowed to overflow and fuel is spilled about the airplane. The airplane should be removed from this vicinity in such cases. A fire extinguisher should be kept available for immediate use.

D. Starting Engines*

The following procedure is recommended for normal starting of the engines.

1. Switch batteries to the "On" position.

2. Switch exhaust gas analyzer to "On" before starting engines.

3. Set both propeller governor controls to maximum "INCREASE R.P.M." (low pitch position).

4. Set propeller control switches to "On" position.

5. Set constant speed-manual selector switch to "Constant Speed" or "Automatic" position.

6. Set carburetor inlet air control to "Cold."

7. Open the engine cowl flaps to "Full Open."

*WARNING: See that Supercharger Speed Control is in low speed position.

8. Set fuel valves as follows: (See Fuel Consumption Notes Below)
   (a) Cross feed valve to "On."
   (b) Engine selector valve to "Both On."
   (c) Main tank selector valve to "Left Main On."*

9. Set Supercharger levers in the full forward (high boost) position.

10. Set mixture control levers to "Full Rich" and throttle control levers at a position to give 700-800 rpm (slightly opened).

11. Operate hand fuel pump slowly to maintain approximately 8 lbs./sq. in. (.56 kg./sq. cm.) fuel pressure during priming. Prime right engine with 2 to 8 full strokes of the primer plunger.

Note: The amount of priming necessary before starting will depend upon operating conditions, particularly temperature. Experience is necessary to indicate the proper amount of priming required for given conditions. Excessive priming has a tendency to wash the oil off of the cylinder walls and to cause scoring or seizing of the barrels and pistons. Priming should, therefore, be the minimum necessary to start the engine. When the engine is warm it will usually be unnecessary to prime. Working the throttle is usually sufficient for starting in warm weather.

Note: If either engine is overprimed, the throttle should be opened wide very slowly and the propeller rotated by hand several turns in the direction of normal rotation, with the ignition switch "OFF." Return throttle to starting position.

12. Continue slow operation of hand fuel pump while pressing in on right starter switch for 20 seconds. Engage starter and integral booster by pulling on starter switch handle at the same time stopping the hand pump. When the propeller has made one revolution, turn master and right engine ignition switches "ON." Slowly pump primer as engine starts to fire. When engine fires smoothly, open throttle slowly to 1000 R.P.M. Shut down if the oil pressure does not reach 40 lbs./sq. in. (2.8 kg./cm^2) a few seconds after starting.

Fuel Consumption Notes

(a) When fuel is carried in the auxiliary wing tanks, it is necessary to set the main tank valve to "AUX. ON", and the auxiliary tank selector valve to either "LEFT OR RIGHT AUX." depending on the desired source of supply, when this fuel is to be used.

(b) The bomb bay auxiliary fuel should be retained for use just prior to use of the reserve fuel in the left main tank. If this is done, greater ease in landing the airplane in an emergency is assured since the largest fuel load will remain in this tank which can be released from the airplane.

(c) Warning: The auxiliary fuel in the bomb bay tank should never be used for starting engines or for take-off and climb since an emergency release of the supply will cause the engines to stop. Select this supply only after obtaining a safe altitude of approximately 2000 ft. (609.6 m.).

*It is necessary to use fuel from the Left Main (Front) Tank first because the return flow from the separators goes into this tank.

13. Press the left starter switch and engage the starter in the same manner as the right, turning the left engine ignition switch on. Operation of the hand fuel pump while starting the left engine is unnecessary as, with the cross feed fuel valve "ON", the right fuel pump maintains pressure for the left engine. Pump the primer and watch the oil pressure as for the right engine.

14. If an engine fails to start after a reasonable number of attempts, consult the Instruction Book for Wright Cyclone Engines (Chapter on Engine Troubles) to ascertain the probable cause.

15. The recommended procedure for starting first the right engine and then the left is for convenience. In starting the right engine, the acceleration of the starter can be heard. After the right engine is running, the acceleration of the left starter can seldom be heard but it can be noted by observing the rate of rotation of the starter hand crank extension shaft visible from the cockpit on the inboard side of the left nacelle.

E. Warming Up Engines

Careful warming up of high power supercharged engines is essential in order to avoid damage. The recommended procedure is as follows:

1. After the engines start, if the propellers are not already at low pitch position, the electric motors will decrease the pitch until the low limit switches operate.

2. Allow engines to run at 800 R.P.M. for a few minutes with the oil pressure gauges showing at least 40 lbs./sq. in. (2.8 kg./sq. cm.).

3. Set throttles to give engine speeds of 1000 R.P.M. Run at this speed until the oil temperature rises slightly (6°C. increase is sufficient) after a definite registering of temperature is observed, or until the temperature reaches 15°C. While running, keep a close watch on engine cylinder head temperatures. If the head temperatures should exceed 235°C., reduce the engine speed. Do not run engines faster than 1000 R.P.M. except for magneto checks. Do not attempt to use more R.P.M. in order to decrease the warming up period.

When oil has been warmed as explained above, turn the fuel cross feed valve "Off" in order to check the individual fuel pressure delivered by each engine-driven fuel pump. After checking, the fuel cross feed valve must be turned to "On" before take off.

Be sure that wheel chocks or brakes are secure. Then smoothly open throttle, one engine at a time, to not more than 76.0 cm. (30 in.) Hg. max. manifold pressure, long enough to check each magneto and fuel and oil pressures. This should give an R.P.M. in the neighborhood of 1800; and should be noted before each flight. After the corresponding R.P.M. for 76.0 cm. (30 in.) Hg. max. is known for the individual engine, any unaccounted-for losses in R.P.M. noted (for a given throttle position) may be attributed to trouble due to carburetor icing, faulty magnetos, or sparkplugs, etc. DO NOT run at this speed more than 30 seconds. While the throttle is open, check that the following items are within the limits specified:

	Low Limit	High Limit
Oil pressure	50 lbs./sq.in. (3.51 kg./sq.cm.)	65 lbs./sq.in. (4.52 kg./cm^2)
Oil temperature (max.)	See paragraph 3 above	190°F.-88°C.
Fuel pressure	3.5 lbs./sq.in. (.25 kg./sq.cm.)	4 lbs./sq.in. (.28 kg./sq.cm.)
Voltmeter	14.4 volts	14.6 volts
Ammeter	Shows charge	----------
Automatic Pilot Oil Pressure (Approx.)	75 lbs./sq.in.(5.27 kg./sq.cm.)	----------
Suction Gauge Vacuum	3 in. Hg. (76.2 mm.)	5 in. Hg. (127.0 mm.)

Close throttle slowly and repeat the operation for the other engine. Open valve and remove condensate from manifold pressure lines.

Note 1: It is essential that cowl flaps be kept fully open regardless of weather for all ground running and taxying in order to insure against overheating the engines.

Note 2: Carburetor air heat should never be used unless icing conditions exist. The excessive use of carburetor air heat lowers the horsepower and shortens the life of the engine. Icing may be noted by erratic readings on the Cambridge Analyzer, and a drop in manifold pressure. **The temperature of the air mixture entering the carburetor shall not be colder than 2°C.**

The mixture must be set to FULL RICH before turning on carburetor air heat, and the mixture then leaned out to obtain the proper Cambridge indicator reading for the power used, and the condition of flight, with hot air.

The carburetor air heater should be turned on FULL first, then reduced as much as possible. This is necessary since it takes much more heat to eliminate ice which may have already formed than to prevent ice from forming.

F. Take-Off

The following procedure is recommended for take-offs:

1. Remove wheel chocks; release brakes.

2. Taxi to end of runway and head into the wind. Recheck the following items:

   (a) Aileron and rudder tab controls in neutral.

   (b) Elevator tab in neutral for all average loadings. (Maximum forward or rearward center of gravity loadings may require a slight modification of zero setting for take-off.)

   (c) Wing Flaps "UP"

   (d) Mixture "FULL RICH"

   (e) Supercharger Regulator "FULL FORWARD" position (High Boost)

   (f) Carburetor Air Heater "COLD" (Unless Warm Air is Necessary)

   (g) Propeller Governor Controls "TAKE-OFF" (Low Pitch - 2200 rpm)

   (h) Fuel Cross Feed "ON"

(i) Fuel Quantity Gauge — Set to Register quantity in tank from which fuel is being used.

(j) Exhaust Gas Analyzer — "ON"

(k) Engine Cowl Flaps — "CLOSE" to 15° - 20° just before starting take-off run.

(l) Cylinder Head Temperature — Do not start take-off with cylinder head temperatures above 205°C.-400°F. or below 120°C.-250°F.

(m) Supercharger Speed Control — Low Speed Position.

Note 1: During take-off and climb if icing conditions are indicated (by an unwarranted drop in manifold pressure), adjust carburetor heat control to maintain proper carburetor temperatures. This should be done as described in paragraphs under Note 2 of Warm Up.

Note 2: In case of failure of supercharger pressure regulator, the throttles can be used to over-ride the high boost position of the regulator controls by moving the throttle levers to the extreme forward position on the engine control unit.

3. Open throttles gradually and evenly, taking care to keep power output of both engines balanced. Do not exceed 100.33 cm. (39.5 in.) Hg. manifold pressure or 2200 rpm.

4. After clearing obstacles (and before one minute), reduce the manifold pressure to not more than 90.6 cm.(35.7 in.)Hg. by backing off on the supercharger levers and letting the throttles stay at take-off position. Next change propeller control setting to not more than 2100 rpm. Note: Always make adjustments in the order given, never the reverse.

5. After reaching an altitude of 500-1000 m., turn fuel cross feed valve "Off." If instructions outlined in paragraph D-8 have been followed, it will be unnecessary to reset fuel valves unless bomb bay fuel is to be used. Re-register fuel quantity gauge selector switch with tank feeding the engines after changes are made.

6. Retract the landing gear.

Note: Take-offs may be made with wing flaps down from 5° to 15° but flight test results show little or no change in distance required to clear a given obstacle. In order to simplify operating technique, it is recommended that all take-offs be made with the wing flaps full up to 0°.

G. Climb

With the installation of the two speed supercharger in the G5 engines, it is advisable to consider five separate types of climbs as:

1. Full Rated Power Climb.

2. Constant Manifold Pressure Climb.

3. Less than Full Power Climb where high supercharger gear ratio will not be used.

4. Climbs of Lower Power where high supercharger gear ratio will not be used.

5. Emergency Single Engine Climb.

Execution of the climbs in the order named should be as follows:

Climb 1 - Full Rated Power Climb

1 (a) After clearing obstacles on takeoff (and before one minute), reduce the manifold pressure to 90.6 cm. (35.7 in.) Hg. by backing off on the supercharger levers leaving the throttles in the takeoff position.

1 (b) Adjust the propeller governor controls to give 2100 R.P.M. with the aid of the synchroscope.

1 (c) Retract the landing wheels.

1 (d) As the climb continues, gradually reduce the manifold pressure to maintain constant horsepower (850 H.P.) up to critical altitude where the manifold pressure will be 86.6 cm. (34 in.) Hg.

1 (e) Adjust the mixture until the indicator on the exhaust gas analyzer dial coincides with the existing manifold pressure. (See Paragraph M-1, Operation.) Do not allow cylinder head temperatures to exceed 260°C. - 500°F. or over 205°C. for periods of more than 15 minutes.

In unusually hot weather, it may be desirable to open the engine cowl flaps to as much as 35° during climb. If the temperature should continue to rise, the gas mixture should be slightly enriched. A cowl flap setting of 15° to 20° should be ample for all strut air temperatures up to 38°C. - 100°F.

1 (f) Low gear ratio should be used at all altitudes for which rated power can be obtained. This means that high gear ratio should not be used below 3000 m. (approx. 10,000 ft.). In making a full rated power climb, shift the gears shortly after passing 3000 meters as follows:

(1) Throttle back and reduce the airspeed of the airplane until it is noted that the engine r.p.m. has fallen off to below 1500 R.P.M. Then with a decisive movement of the speed control lever, shift to high gear ratio.

It is important that the lever be moved fully to the end of its travel in one movement. If this is not done, the clutch may not be engaged in either high or low gear ratio with the result that the impeller will loose its rotational speed. After this has happened further attempts to engage the gears will cause excessive loads on the gear train and consequent overheating of the clutch.

(2) Continue the climb above 3000 m. at 750 H.P. by fully advancing the throttles and adjusting the supercharger controls to 89.6 cm. (35.3 in.) Hg. manifold pressure. As altitude increases, gradually reduce the manifold pressure to 85 cm. (33.5 in.)Hg. at 4600 m. (15200 ft.) critical altitude. Beyond this point the throttles are full open and the manifold pressure will decrease with altitude.

1 (g) For full power climbs with normal full load, the best rates of climb are obtained at the following calibrated indicated airspeeds:

Sea Level	(0 ft.)	202 km./hr.	(125.5 mi./hr.)
1000 m.	(3280 ft.)	198 km./hr.	(125.0 mi./hr.)
2000 m.	(6561 ft.)	193 km./hr.	(121.9 mi./hr.)
3000 m.	(9842 ft.)	186 km./hr.	(115.4 mi./hr.)
6000 m.	(19684 ft.)	166 km./hr.	(103.1 mi./hr.)

Climb 2 - Constant Manifold Pressure Climb

This climb may be accomplished where a full power climb is not required.

2 (a) Should the pilot desire to take advantage of the supercharger regulators to hold the manifold pressure constant during a climb, he should start the climb at 86.6 cm. Hg. which will be held up to first critical altitude.

2 (b) At 3000 meters altitude, shift to high gear ratio, and set the regulators to maintain 85 cm. Hg.

2 (c) These manifold pressures must be set at the beginning of each section of the climb so that limiting manifold pressures for the engines will not be exceeded when altitude is reached. It will be noted that horse power at sea level is less than rated power.

Climb 3 - Less Than Full Power Climb Without High Gear Ratio

3 (a) Proceed as described in paragraphs 1 (a) through 1 (e) for full rated power climb.

3 (b) Above 3000 m. the climb will be continued in low gear ratio with the throttles fully open; the manifold pressure and the horse power will decrease normally with increasing altitude.

Climb 4 - Low Power Climb Without High Gear Ratio

This type of climb may be made where a long range flight is to be undertaken and where fuel economy is a vital factor. This climb is often referred to as a "cruising power climb."

4 (a) After takeoff (and before 1 minute) reduce the manifold pressure to 74.0 cm. (29 in.) Hg. by backing off the supercharger levers.

4 (b) Adjust the propeller governors to give 1900 R.P.M. with the aid of the synchroscope.

4 (c) With these adjustments the engines will develop 600 BHP. which should be held constant by uniformly reducing the manifold pressure with altitude. The Cambridge indicator should be held in coincidence with the manifold pressure as the climb continues.

4 (d) Maintain the engine cowl flaps as nearly closed as possible. At head temperatures above 180°C.-356°F. there is a slight loss of engine power. This limit should be held at all times that weather conditions permit. An extreme limit of 260°C.-500°F. is allowable for periods of 15 minutes. Where flying is done in extremely hot weather for protracted periods, the limiting head temperature is 205°C.-400°F.

4 (e) The best rates of climb for this type of climb are obtained at the following calibrated indicated airspeeds:

Sea Level	(0 ft.)	185.0 km./hr.	(115.0 mi./hr.)
1000 m.	(3281 ft.)	187.4 km./hr.	(116.5 mi./hr.)
2000 m.	(6562 ft.)	187.8 km./hr.	(116.8 mi./hr.)
3780 m.	(12400 ft.)	185.8 km./hr.	(115.5 mi./hr.)
5180 m.	(17000 ft.)	182.5 km./hr.	(113.5 mi./hr.)

Climb 5 - Emergency Single Engine Climb

5 (a) Performance and flight control are so greatly improved by feathering the propeller and closing the cowl flaps on an inoperative engine that it is imperative that the pilot take advantage of these features.

5 (b) In case an emergency arises while the landing gear is down, the pilot should immediately start retracting the wheels and feathering the propeller of the inactive engine. These items are electrically operated and require negligible time to control. The landing gear particularly has a detrimental effect on performance.

5 (c) Even with the landing gear down, the airplane will climb slowly on takeoff power (2200 rpm. and 100.3 cm.Hg. at sea level). Under such an emergency, the pilot is allowed to use takeoff power for 5 minutes. In this case full rich mixture should be used.

This permits time to retract the cowl flaps on the inoperative engine and to open the flaps in the working engine approximately one-half or less if weather conditions permit.

5 (d) The same temperature limits apply for single engine climb as for the other climbs using a richer mixture to govern these limits.

6. During any climb the following limits should be held:

	Low Limits	High Limits
Oil pressure	50 lbs./sq. in. (3.51 kg./cm^2)	65 lbs./sq. in. (4.52 kg./cm^2)
Oil Temp. (Max.)	40°C.-104°F.	88°C.-210°F.
Fuel Pressure	3.5 lbs./sq. in. (.25 kg./cm^2)	4 lbs./sq. in. (.28 kg./cm^2)
Cylinder Head Temp.	(See Paragraph H below)	205°C.-400°F. Continuous Operation 260°C.-500°F. (15 minute period only)
Voltmeter	14.4 volts	14.6 volts
Ammeter	(Shows charge)	-----------------
Suction Gauge Vacuum	3 In. (76.2 mm) Hg.	5 In. (127 mm) Hg.

H. Cruising and Level Flight

The maximum cruising limits set by the engine manufacturer are 600 H.P., 1900 R.P.M., 74 cm. (29 in.) Hg. manifold pressure, and 188°C. (370°F.) cylinder head temperature. These limits should not be exceeded while cruising.

To prolong the life of the engines it is desirable to limit cruising operation of the engines to 500 H.P. and 1850 R.P.M. Curves showing manifold pressure plotted against altitude for cruising conditions may be found at the end of this section.

For maximum-range cruising, numerous factors, such as initial gross weight, external bombs carried, altitude, etc., affect the operation, and it is necessary to prepare a detailed flight plan prior to take-off. Consult the curves found at the end of this section for data in preparing detailed flight plans.

For maximum power operation use Low Blower ratio from sea level to the altitude where full throttle power coincides with rated power in high ratio. (3000 m. - 10,000 ft.) In order to conserve fuel while cruising DO NOT use high ratio at altitudes where power required can be maintained in low ratio. When changing to high ratio, throttle engines sufficiently to prevent exceeding rated manifold pressure. When changing from LOW to HIGH ratio, enrich the mixture first and readjust for the new condition after the ratio has been changed. Avoid unnecessary engagement of clutches, do not pause when shifting, and be sure control lever is against the respective stops for high and low ratio. Allow five minutes between each shift to permit dissipation of heat generated by clutch changing.

For rated power in level flight adjust the superchargers to not more than 86.36 cm. (34 in.) Hg. M.P. and set propellers for 2100 R.P.M. The manifold pressure will be maintained regardless of altitude, R.P.M., or temperature provided the critical altitude for the manifold pressure and R.P.M. selected is not exceeded. Above critical altitude the manifold pressure will decrease in the normal manner with increasing altitude.

Do not exceed 90.6 cm. (35.7 in.) Hg. manifold pressure (except for short periods during takeoff).

With the above conditions for cruising at a farily constant altitude the propeller constant speed-manual control switch can be turned to "MANUAL" thus fixing the propeller pitch. Any deviations from the desired engine speed may be made by pressing the momentary contact switch, causing a consequent increase or decrease of pitch. This procedure will save wear in the propeller motor unit and prolong its life.

I. Flight Restrictions

The manufacturer will not be responsible for results if the following maneuvers are performed: loops, spins, rolls, Immelmanns, dives, or inverted flight.

The permissible range of Center of Gravity location for various loadings is defined as follows: (M.A.C. means Mean Aerodynamic Chord.)

	Wheels Extended	Wheels Retracted
Maximum Forward Position, in percent, M.A.C.	22.78	24.12
Maximum Rear Position, in percent, M. A. C.	27.00	28.29

It is recommended, however, that the airplanes are not flown with a center of gravity forward of 25% or aft of 27% M.A.C. When these conditions are not obtained with normal loading, ballast should be used where necessary to obtain the proper balance. Best flying characteristics are obtained by taking off with the center of gravity well forward; use the forward fuel first; then land with the center of gravity aft. This will improve stability during flight, and landing at the end of the mission.

The Model 139-WH3 airplane is designed to permit a steady dive at 300 m.p.h. with normal gross weight of 15,400 pounds (6985 kg.). From this speed pullouts can be made provided the acceleration does not exceed 3.0 g.*

Due to the addition of special equipment the gross weight of the Model 139-WH3 is greater than the stress analysis weight. This in addition to the possibility of rough control may cause the pilot to exceed the specified acceleration. Therefore, the following restrictions are imposed in the interest of safety.

Do not exceed the following speeds or accelerations for the gross weights noted.

Weights	g* (Acceleration		
	260 MPH	270 MPH	285 MPH
Normal Gross Weight (with Special Equipment) 15628.5 lbs. (7088.9 kg.)	5.4	4.6	3.0
Overload Gross Weight (Increased Range) 17518.5 lbs. (7946.2 kg.)	4.8	4.1	***
Overload Gross Weight (Maximum Range) 18414.6 lbs. (8352.7 kg.)	4.5	**	**
Overload Gross Weight (Maximum Armament) 18780 lbs. (8518.4 kg.)	4.4	**	**

*Note: This "g" includes the material factor of 1.5. For applied accelerations, divide the above values of g by 1.5.

**DO NOT FLY ABOVE 260 miles per hour (418 km./hr.)

***DO NOT FLY ABOVE 270 miles per hour (434 km./hr.)

Complete Weight Data for all conditions is given at the beginning of these Piloting Instructions.

J. Wing Flap Operation

It is recommended that the flap angle be limited to 40°. The controls provide for a movement of 50°, but the full travel should be used only when it is desired to obtain the shortest possible landing roll. Never exceed an air speed of 209 km./hr. (130 mi./hr.) with the flaps down. As the flap angle is increased, the gliding angle of the air plane must also be increased. If the flap control valve handle is turned to "Flap Up" while the airplane is in flight with the flap down, the flaps will be instantly raised due to air pressure with a resulting loss in lift. Pilots should familiarize themselves with this characteristic, but it should be demonstrated only when there is sufficient altitude, as the loss in lift is rapid, necessitating equally rapid corrective forces being applied by the elevator control

K. Landing

The recommended procedure is as follows:

1. Be sure supercharger speed control is in "LOW SPEED" position.

2. Turn automatic pilot servo control to "Off." (On airplane equipped with Automatic Pilot.)

3. Turn fuel cross feed valve "ON."

4. Change to wing tank fuel supply if bomb bay tank is being used.

5. Turn propeller constant speed-manual control switch to "AUTOMATIC."

6. Adjust propeller governor at 2100 rpm

7. Lower the landing gear. Check the landing gear position indicator and be sure that the indicator light is "ON" indicating that the landing gear locks are engaged. Should the light not appear, engage crank by depressing thumb button and turn clockwise - hard. If the throttles are closed before the landing gear locks are engaged, the vibrator on the left rudder pedal will start operating indicating to the pilot that the landing gear is not fully down.

8. Move supercharger pressure regulator controls to "HIGH BOOST" position.

9. Set the mixture controls full "RICH."

10. Set the carburetor air heat to "Cold" except under icing conditions when the setting is left to maintain temperatures given under Warm-Up procedure.

11. Turn the wing flap control valve to "DOWN" and lower the flaps. A flap setting of approximately 40° is recommended, and the full down position of 50° need be used only when it is necessary to make the shortest possible roll. Keep the airspeed below 209 km./hr. (130 mi./hr.).

12. While lowering wing flaps, adjust elevator trim tab to reduce loads on the controls. For the approach glide and landing, the elevator tab control should be set full "NOSE UP."

13. Sharp turns on rough landing fields should be avoided as this maneuver when executed with one brake locked may place high stresses in the tail wheel assembly attaching fittings, and in the main landing wheels.

14. For a normal landing maintain a gliding speed of approximately 150-160 km./hr. (93-100 mi./hr.) or higher, depending upon the load. For the shortest possible landing with light load the airspeed in a glide may be held as low as 120 km./hr. (75 mi./hr.). The high drag caused by the extended flaps makes it necessary to glide with the nose well down, or in a rather steep path, in order to maintain speed with power off.

15. Hold the glide until fairly close to the ground and level off rather abruptly. Leveling off gradually, beginning at a considerable height above the ground, may result in a premature stall because of rapid deceleration caused by the high drag of the flaps.

16. Apply brakes evenly and carefully after landing to avoid possible ground looping. Do not use brakes unnecessarily.

17. After landing, raise the flaps to the full "UP" position before taxying.

Important: In event of a forced landing on the water or in a swamp, land with the wheels up.

L. Stopping the Engines

1. Open the engine cowl flaps "full open."

2. Run engine at 600-800 R.P.M. until cylinder head temperatures drop below 150°C. 300°F. (If absolutely necessary to stop engines before properly cooled off, the engines should be run at 1000-1200 R.P.M. for a few seconds.)

3. Move the mixture controls to full "LEAN" position.

4. When engines cease firing, turn ignition switches "OFF."

5. Leave ignition switches "OFF" and mixture controls full "LEAN" to prevent accidental starting.

6. Switch the exhaust gas analyzer "OFF" after the engines have stopped. (See paragraph M-13.)

7. Move battery cut-out switch to the "OFF" position.

8. Apply brakes and lock the controls if the airplane is to be left standing without a ground crew.

9. See instructions, Section III, paragraph A of the Maintenance Manual for anchoring the airplane out-of-doors.

Operation of Accessories

A brief resume covering the operation of certain airplane accessories that are not described in the foregoing is given in the following paragraphs. A thorough study of these data is recommended to all users of these airplanes.

M. Control of Mixture by means of the Cambridge Mixture Indicator

To prevent unnecessary wear on the engines and at the same time obtain maximum fuel economy requires careful and intelligent use of the mixture control. With the constant speed propellers, the older conventional methods of setting the mixture by leaning out until a drop in r.p.m. is obtained, is no longer practicable. The Cambridge Mixture Indicator provides a more ready method of determining best mixture by automatic indication.

These airplanes are equipped with a two-engine, dual-dial type exhaust gas analyzer which indicates the ratio of the weight of fuel to the weight of the air entering the engine. This instrument provides a suitable means of adjusting the carburetor mixture when using a constant speed propeller.

Adjustments

In any flight where maximum fuel economy or maximum power is desired, the fuel-air ratio entering the engine plays a very important part. The use of a mixture which is too lean may also result in serious damage to the engine. Therefore, at fairly frequent intervals and immediately before or after any flight where the maximum performance of the engines is used, the checks and adjustments as described in Section X, paragraph J, of the Maintenance Manual should be made.

Operation

1. The dial of the exhaust gas analyzer is calibrated in fuel-air ratio as well as having a scale indicating manifold pressures. For normal operation the pilot should adjust the mixture control so that the pointers on the indicator, (the top pointer for the left engine and the lower pointer for the right engine) will index with a manifold pressure on the indicators which corresponds with the manifold pressure at which the engine is operating, as indicated by the manifold pressure gauge. Only under exceptional or emergency conditions requiring extremel low fuel consumption, should the indicator read less than the manifold pressure. Under these conditions, the mixture may be leaned out, provided the engine temperatures are carefully watched and detonation avoided. Detonation may be noted by puffs of black smoke coming out of the exhaust, and by rough engine performance. When detonation occurs, the mixture must be immediately richened.

2. For take-offs under 1200 m. above sea level, keep the mixture control handle full "Rich."

3. Watch the cylinder head temperatures and use a richer mixture if the temperatures approach their upper limits (to prevent exceeding the limits).

4. During the first times the mixture control is used with the mixture indicator as a guide, some difficulty may be experienced in getting the pointer to stop at the desired point. It must be remembered however, that the fuel-air ratio is affected by a number of factors other than the actual position of the mixture control handle, such as changes in altitude, air temperature, carburetor air pre-heat, throttle, and supercharger regulator control position, fuel pressure, airspeed, with the consequent changes of "ram", etc., and the mixture control handles will require readjustment after any change in the above mentioned operating conditions. After some experience a very accurate setting of the mixture may be accomplished without difficulty, provided the instrument is functioning properly. (See Paragraph 13--"Warnings".)

5. After a change in fuel-air ratio the instrument will not indicate the new ratio immediately. This lag is due to the necessity of replacing the sample of old gas in the analyzer cell by a sample of the new gas. The pointer will start to move in a few seconds and several minutes may be required to indicate the total change. Because of this lag, changes in fuel-air ratio towards the lean side should be made with caution.

6. When a pointer appears to fluctuate erratically or to move gradually from the lean to the rich side of the scale, under apparently stabilized conditions with a lean mixture setting, "detonation" may be indicated. When these symptoms appear, richen the mixture immediately to avoid damage to the engine, then reset the mixture using a richer mixture than before. Increased cylinder head temperatures, and generally rough engine operation accompanied by puffs of black smoke from the exhaust are also indications of detonation.

7. Carburetor icing may also be indicated by a gradual movement of the pointer to the rich side of the scale for no apparent reason. A drop in manifold pressure is also a good indication of ice in the carburetor.

8. During progressive leaner operation of the engine, the Cambridge indicator will move toward the .065 fuel-air ratio. As mixtures become leaner than this reading,the indicator hand starts returning toward the rich direction which is a result of the decrease of percentage of carbon dioxide present, and an increase in the hydrogen in the exhaust due to imcomplete combustion of the lean mixtures. This effect at extremely lean mixtures should also be noted and understood by the operator of the engine.

9. When the carburetor air heater is applied, the mixture very definitely goes rich. Sudden application of the heater while flying with a normally rich mixture may cause considerable loss of power or stopping of the engines. This is caused by a reduction in the amount of air entering the carburetor and a resulting excessively rich mixture. The condition should be remedied by promptly leaning out. When the air heater is shut off,the mixture goes very definitely lean, leading to possible detonation. Therefore, the mixture should be made richer before shutting off the air heater.

10. If the pointer stays at the center of the scale near the "A" (air point) position it may be that the instrument switch is off, or that the sampling line from the exhaust stack to the analyzer cell is broken.

11. If the pointer, under apparently stabilized conditions, moves to the lean side of the scale, a low fuel pressure may be indicated, in which case the red Fuel Pressure Warning Light on the instrument panel should be on.

12. The indication of a lean mixture during descents with a low throttle and a full rich mixture control position is caused by a combination of high ram and low fuel flow and does not indicate a dangerous condition.

13. Warnings

a. Land with the mixture control handle full rich unless the landing field is at an abnormal height above sea level, (above 1200 meters or 3950 ft.).

b. Full rich mixture should normally be used for take-off from any field below 1200 meters (3950 ft.) altitude.

c. When setting the mixture against the wheel chocks for a take-off from a high altitude field, the indicator should never read less than the manifold pressure for take-off, and it should be remembered that the mixture will go leaner as the speed of the airplane is increased due to increased ram.

d. If the exhaust gas analyzer switch is left in the "off" position while the engine is running, a film of oil may collect on the filaments and cause erroneous indications for as long as two hours after the switch is turned on. To avoid difficulty the switch should be turned on before starting the engines and kept on at all times while the engines are running.

N. Automatic Pilot - Sperry Gyropilot (For Airplanes so Equipped)

1. GROUND CHECK

Prior to take-off the Gyropilot should be given a ground check by the pilot, inspector, or line mechanic responsible for releasing the airplane as ready for service, using the following procedure

(a) Check for air in Servos. Before starting engines, set the airplane controls approximately neutral and set Gyropilot engaging lever "ON." Apply light pressure each way to each control. Controls should act as though locked. If there is a resilient action it is an indication of air in the servo cylinder which should be worked out during the engine run-up by working controls back and forth with the Gyropilot "Off." While working out air, hold each control at each extreme position for about 30 seconds to allow time for air to be carried from the servo to the sump tank. Do not mistake springing of the control cable system with the resilient action of air in a servo cylinder. Servo piston movement is indicated by movement of follow-up indices on control unit dials.

(b) Check Vacuum. Vacuum should not be less than 3 inches (7.5 cm.) of mercury at 1000 r.p.m. or more than 5 inches (12.7 cm.) of mercury with engines at maximum ground r.p.m. (The vacuum is adjusted at the relief valve provided on each pump and by a Sperry Relief Valve No. 641240, accessible from the bomber's compartment by unbuttoning the top curtain.

(c) Check Oil Pressure. Close speed control valves when checking oil pressure. It should be within 10 lbs./sq.in. (.7 kg./sq.cm.) of recommended operating pressure.

(d) Uncage Bank and Climb Gyro. If airplane is not level, gyro should move slowly toward correct indication of the attitude of the airplane on the ground when uncaged.

(e) Set and Uncage Directional Gyro.

(f) Open Speed Control Valves. A control will not operate unless its speed control valve is open.

(g) Set Turn Control "OFF." (If Turn Control is Installed.)

(h) Set Level Control "OFF."

(i) Set Follow-Up Indices to match gyro indications using the Rudder, Aileron, and Elevator knobs when manual controls are approximately neutral.

(j) Engage Gyropilot

(k) Test Operation of Gyropilot by turning Rudder, Aileron, and Elevator knobs noting that controls move both ways in the correct direction and at approximately equal speed each way. ("Up elevator" will probably be slower than "down elevator" due to the weight of the surface.) Slow aileron or rudder one way and fast action in the opposite way, or control in one direction only, is indicative of maladjustment which should be corrected in accordance with service instructions on Trouble Shooting.* Set Turn Control successively "RIGHT" and "LEFT" to check operation of rudder follow-up knob and card if Turn Control is provided.

Note: Also check lights, spare bulbs, and quantity of servo oil in tank.

2. Operation of Automatic Pilot

After takeoff the flight of the airplane should be trimmed by means of the tabs for "Hands Off" condition before engaging the Gyropilot. Trimming the airplane first will prevent oscillation of controls due to the Gyropilot attempting to correct the unstable condition (the engaging lever is located above the longeron on the right side of the pilot's cockpit). The Automatic Pilot then assumes full control of the airplane. However, it is necessary to occasionally check the Directional Gyro with the magnetic compass and with the drift meter, direction finder, and charts to maintain the desired course against wind drift. The directional controls are located on a panel installed on the right side of the cockpit. An Oil Pump and a Vacuum Pump (which normally operate the Automatic Pilot) are mounted on the left engine; also a Vacuum Pump is mounted on the right engine, thus providing a double source of vacuum (but not oil pressure) through the vacuum selector valve. This assures operation of the Flight Gyro Instruments in case either engine should fail. However, if the left engine fails or is stopped, the Automatic Pilot will cease to function, due to loss of oil pressure to the Servo unit which operates the Surface Controls, hence the Automatic Pilot must be disengaged and the airplane flown manually.

Loss of oil pressure however, does not render the Bank and Climb Gyro and Directional Gyro inoperative as these instruments may be run on the suction produced by the vacuum pump on the right hand engine.

Note: The following information is based on the Sperry Instructions for the Operation and Installation of the Sperry Gyropilot (Bulletin 15-726C).

(a) ENGAGING THE GYROPILOT

Several things should be checked or performed prior to engaging the Gyropilot. These are listed for convenience of the pilot. Familiarity with the Gyropilot will soon reduce this procedure to a simple routine.

*Refer to Sperry Instructions Bulletin 15-726C.

(1) Check vacuum.	Desired vacuum is 4 inches (10 cm.) of mercury. It should not be less than 3 inches (7.5 cm.) or more than 5 inches (12.7 cm.)
(2) Check oil pressure.	Best operating pressure will have been determined during original tests.
(3) Open speed valves.	A closed speed valve locks its control in position when the Gyropilot is "ON." It is, therefore, important that the valves be open prior to engaging the Gyropilot.
(4) Set level control to "OFF."	
(5) Check Directional Gyro setting and be sure both gyros are uncaged.	
(6) Trim the airplane for "Hands Off" condition.	
(7) Set follow-up indices to coincide with gyro indications.	Rudder follow-up card should match Directional Gyro; Bank index should match mark at top of Bank and Climb Gyro dial; and Climb index should match mark at right end of the miniature airplane bar.
(8) Set Turn Control to "OFF."	(If Turn Control is provided.)
(9) Engage Gyropilot slowly.	By holding to the controls as the Gyropilot is engaged the pilot can feel when the Gyropilot is taking over and functioning.

(b) SPEED CONTROL VALVE SETTING

When the Gyropilot is engaged there may be an oscillation of one or more of the controls with the speed control valves wide open. The valve corresponding to the oscillating control should be slowly turned toward closed position until the oscillation ceases. A valve should not be completely closed as this stops oil flow to the servo and locks the control. After the speed valve has been closed enough to stop oscillation in a control, the setting knob for that control should be moved back and forth a small amount to be sure that control operation has not been stopped by closing the speed valve too far. Speed valve settings should not have to be changed unless it is desired to materially increase the speed of control in rough air. The numbers on the valve dials represent turns of the valve and may be used as a reference for bringing the valve back to a desired setting. When there is no oscillation present, the Speed Control Valves should be left wide open unless reduced speed of control is desired.

Revised 7/8/38.

(c) DIRECTIONAL CONTROL

Directional control in the Gyropilot is based on the Directional Gyro which must be set with the magnetic compass and rechecked at periodic intervals. The average drift of a Directional Gyro should not be more than 3° in 15 minutes. A drift of 5° in 15 minutes is permissible on one heading providing the average on the four cardinal headings does not exceed the 3° in 15 minutes. Since the Gyropilot controls to a set heading on the Directional Gyro, the drift will cause a corresponding change in the magnetic heading of the airplane. When the airplane is only two or three degrees off the desired heading by magnetic compass a small adjustment of the rudder knob will suffice to correct the heading. When there is an appreciable difference in reading between the compass and Directional Gyro, the Gyropilot should be disengaged for a moment while the Directional Gyro is being reset. An alternative method is to leave the Gyropilot engaged, close the rudder speed valve for a few moments (which locks the rudder at center) while the Directional Gyro and follow-up are being reset. Rudder control is restored when the speed valve is re-opened.

(d) LATERAL CONTROL

Lateral control in the Gyropilot is taken from the Bank and Climb Gyro. The aileron knob can be set for either level flight or to any angle of bank up to 30° for use in either an automatic turn (using turn control) or in a turn where the turning is controlled by continued manual operation of the rudder knob.

(e) LONGITUDINAL CONTROL

Basic longitudinal control is taken from the Bank and Climb Gyro. The desired longitudinal attitude is set by means of the elevator knob. Use of the level knob permits automatic control of altitude. When the level knob is in the "OFF" position, control is purely to an attitude which is controlled by the elevator knob. To use the level control upon reaching the altitude at which it is desired to fly: (1) Turn the Gyropilot "OFF" as soon as the plane is leveled off and see that the LEVEL knob is also turned to "OFF"; (2) Maintain the plane in level flight and turn the LEVEL knob to "LEVEL" with the Gyropilot remaining disengaged; (3) When displacement of elevator follow-up index pointer has ceased, re-synchronize this pointer with miniature airplane bar by means of ELEVATOR knob; (4) Re-engage Gyropilot.

With the LEVEL control in operation the airplane will be automatically maintained at a practically constant pressure altitude within normal operating limits.

(f) MANEUVERS

Outside of straight flight which may be either level, or climbing, or descending, the only maneuvers that it should be necessary to perform with a Gyropilot are turns and spirals. Course changes of a few degrees may be made as flat turns, in which case it is only necessary to rotate the rudder knob slowly until the airplane reaches the new heading. When Automatic Turn Control is used, the Turn Control handle is moved to right or left (depending on the direction of turn desired) causing a small air motor in the Directional Gyro Control Unit to drive the rudder knob and follow-up card in the proper direction to produce the turn. As the turn starts, the aileron knob should be turned to produce the proper bank for the turn. As the desired new heading is approached, the Turn Control should be returned to zero and the airplane leveled out by means of the Aileron knob. After the Turn Control has been set to "OFF", it will be noticed that the airplane will continue to turn at a decreasing rate and the Directional Gyro and Rudder Follow-up cards will continue to travel together. This is necessary to accomplish removal of the rudder control which was applied to create the turn. If the cards are still moving at a noticeable rate as the airplane approaches the desired Directional Gyro heading for straight flight, set Turn Control for opposite turn which will speed up neutralization of rudder. For control in a spiral the required climb or descent setting is made in conjunction with the turn setting in the same manner as in straight flight.

(g) OPERATION OF AUTOMATIC PILOT UNDER CONDITIONS APPROACHING A STALL

(1) When flying by means of automatic pilot under conditions approaching a stall, the human pilot must carefully guard against the airplane falling into a spin as the result of some additional stall-producing action such as a gust, a small amount of ice forming on the wing, or use of de-icers when the airplane is so equipped.

(2) Following are the reasons.

(a) With the automatic pilot in use the human pilot does not receive from the controls the usual warning of impending stall that results from the irregular (burbling) lift.

(b) Since the automatic pilot maintains the lateral, longitudinal, and directional attitude that is set into it, should the airplane start to spin, the action of the automatic pilot as the nose drops will be to give the airplane "UP" elevator - just the opposite of the procedure for recovery from a spin.

(h) USE OF THE AIRPLANE TRIMMING CONTROL

Changes in flight attitude, power, altitude, and load shifts will affect the fore and aft trim of the airplane and cause the Gyropilot to hold the elevator against the out-of-trim condition so as to hold the airplane to the set-in attitude. This may result in an oscillation of the elevator control or in overloading the pilot which may be dangerous at speeds near stalling unless the airplane is kept in trim. The trim of the airplane can be checked by disengaging or re-engaging the Gyropilot for a few seconds and noting whether the airplane tends to nose up or down. A trim correction should then be made with the elevator trimming tab.

(i) On airplanes equipped with individual by-pass valves for each servo, only the elevator control need be turned off to check trim. When by-passing a single servo cylinder, close the speed control valve to that control so that oil pressure to the other two controls will not be by-passed. In rare cases better control may result with a slight loading of the elevator control in one direction. In order that the human pilot will not have to suddenly apply a large force to the elevator to hold the airplane when the Gyropilot is disengaged, the airplane should be kept approximately in trim during Gyropilot operation.

MANUAL CONTROL

When it is desired to resume manual control it is only necessary to move the engaging lever to the "OFF" position and take over the controls. As an added safety measure, servo relief valves are provided which allow for immediate emergency overpowering of the Gyropilot by applying about twice normal force on the controls.

O. Supercharger Operation

1. General

The engine manifold pressure is automatically maintained at varying altitudes up to critical by means of the Eclipse M-3217A Supercharger Regulator installed on each engine and remotely controlled by means of the engine control unit located on the left side of the cockpit.

The supercharger regulator installation consists mainly of two interconnected units:

(a) A pressure selector or regulator unit which contains adjustments and stops for "High Boost" and "Low Boost" manifold pressure settings. This unit is controlled by the long levers on the engine control unit through a system of "Shakespeare" controls, push rods, and bell cranks. It is adjusted to the following limits:

"HIGH BOOST" for Take-Off $39\frac{1}{2}$ In. Hg. (100.33 cm. Hg.)
"LOW BOOST" for Cruising 20 In. Hg. (51.0 cm. Hg.)

The pilot can set this unit to High or Low Boost position or to any intermediate position.

(b) A spring loaded hydraulic piston normally operated by oil pressure from the engine is equipped with a bellcrank which actuates the carburetor butterfly valve through a push rod. The throttle lever for the corresponding engine is connected to the lower arm of the bell crank.

Between 20 In. (51.0 cm.) Hg. "Low Boost" and $39\frac{1}{2}$ In. (100.33 cm.) Hg. "High Boost" the throttle levers are left inoperative when the supercharger controls are used.

2. Throttle Controls

The hand throttle is designed to work through three separate ranges described as follows:

(a) The first range through which the throttles directly operate the carburetor butterfly valve provides a control from fully closed to a position equivalent to the "Low Boost" setting of the supercharger regulator. This range is used for Idling the engines, Taxying and for cruising below the "Low Boost" limit.

(b) The second range provides additional movement of the hand throttles between High and Low Boost setting of the supercharger regulator. The engine power can at all times be controlled entirely by the throttle levers in the cockpit. When the pressure selector levers are in "High Boost" position, manifold pressures below take-off pressure can be obtained with the hand throttles. When the pressure selector lever is in "Low Boost" position and lower manifold pressures are desired than that given by the regulator, the throttles can be used to accomplish this result. However, under this condition there will be a considerable portion of the throttle travel in which the manifold pressure is not affected as the throttle movement must overcome the regulator compensation. When the pressure selector lever is in "Low Boost" or any intermediate position, the regulator may also be overcontrolled to obtain manifold pressures in excess of the regulator setting by means of the throttle levers in the cockpit.

During ground running, therefore, and during flight operation in a glide where the desired manifold pressure is either above or below the manifold pressures for which the regulator is set, the throttles will be used to control the engine. For normal operation the throttle control will be moved to the open position on the engine control unit equivalent to the "High Boost" position of the supercharger regulator, and the manifold pressure will be controlled entirely by the adjustment of the pressure selector levers.

(c) The remaining movement of the hand throttles through the third range to the extreme open position provides an "Overcontrol" of the pressure regulator and operates directly on the carburetor valve. This range is used for Emergency Only and provides a means for obtaining maximum manifold pressure in event of malfunction of the regulator piston. It will be noticed that a slight additional hand pressure is required to operate the hand throttle beyond "High Boost" position into this range.

3. Use of Controls

(a) Starting, Idling, and Taxying

The manifold pressure selector levers are to be set in the full "High Boost" position when starting the engines, or for idling and taxying. The hand throttles are used during these operations.

(b) Take-off

The pressure selector levers are left in the "High Boost" position and the hand throttle levers are moved forward to the forward end of Range #2 (just before overcontrol of the supercharger regulator takes place). If the throttle is moved too quickly, the take-off manifold pressure may be exceeded momentarily, but with normal throttle movement the compensation will be adequate.

(c) Climb

For climb the throttle levers are to remain in the same position as for take-off (at the forward end of Range #2) and the pressure selector levers adjusted to give desired climbing manifold pressure. The regulator will maintain a fixed manifold pressure throughout the climb unless a change in setting is made by the pilot. This regulation gives increasing power up to critical altitude but since the climb is of such short duration to this altitude and emergency powers are not exceeded, it is felt to be unnecessary to try to follow a constant power curve.

(d) Cruising

Following the climb the pressure selector levers should be adjusted with the throttle control levers in the same position as for climb. When the regulator setting is established the propeller governor controls should be set for desired cruising R.P.M., or the propeller pitch should be fixed with the automatic-manual switch turned to MANUAL control. (See Paragraph H, Cruising and Level Flight.) The regulator will maintain fixed manifold pressure regardless of altitude, R P.M., or temperature provided the critical altitude for the manifold pressure and R.P.M. selected is not exceeded. Above critical altitude for the conditions selected the manifold pressure will fall off in the normal manner.

(e) Landing

The pressure selector levers should be moved to the "High Boost" position prior to landing, and the manifold pressure controlled by the hand throttles only. In case of an emergency, therefore, it will only be necessary to move the throttles completely forward to obtain emergency power.

P. Propeller Operation

The electrical controllable pitch propellers with automatic control governors require very little attention from the pilot. The location of the controls and notes as to their use are given in paragraph B-3(d) of this Section. A brief resume of the function of these controls is as follows:

(1) Governors

The propeller governors will not operate and control the pitch of the propeller blades until the Safety Control switches are "ON" and Constant Speed-Manual Selector switch is placed at AUTOMATIC. With these conditions the governors will remain in the INCREASE R.P.M. (low pitch) position until the engine speed reaches 1200 rpm. The governor control wheel support bracket is equipped with a nameplate indicating the position at which the pointers are set for take-off R.P.M. Before starting the engines, the controls should be set for this condition.

During climb, level flight, and maneuvers, the governors hold the engine speed constant by varying the pitch of the propellers. If a different engine speed is desired at any time during flight it is only necessary to adjust the governor controls slowly until the tachometer registers the desired speed.

During level flight while cruising for some distance at a fairly constant altitude, it is desirable to turn the Constant Speed-Manual Selector switch from "AUTOMATIC" to "MANUAL." The propeller will then act as a fixed pitch propeller, and any deviations from the desired engine speed may be rectified by pressing the momentary contact "Manual Control" switches with a consequent pitch change. By this procedure any desired pitch within the operating range of blade angles may be set and maintained.

When gliding in to land, it is essential that the controls be again switched to "AUTOMATIC" and the governor readjusted to the 2100 R.P.M., (normal rated rpm for these engines), this allows for sudden "gunning" of the engine if necessary.

(2) Feathering the Propellers

The propeller blades can be "Feathered" by putting the control selection switch in the "MANUAL" position, then hold the manual control switch for the propeller being feathered in the "DECREASE R.P.M." position until the propeller ceases to rotate. The operating motor cuts out at 88.6°. Turn the safety switch for this propeller to the "OFF" position.

When feathering a propeller in flight, it is necessary to close the throttle, turn off the ignition switch of the engine on which the propeller is being feathered because the high compression in the cylinders which results when the engine slows down due to increasing the propeller pitch (Feathering) cannot be exhausted fast enough, resulting in a very rough engine.

When the throttle is closed, the warning vibrator on the left rudder pedal will function providing the landing gear is in the "UP" position. This condition is obviated after the propeller is feathered and the engine stopped by opening the throttle on the engine affected, far enough to open the warning switch. This switch will again operate when the other throttle is closed.

CAUTION: When feathering a propeller at any time except during an emergency, it is advisable to shut off the gasoline supply and run the gasoline out of the engine, then proceed with the feathering. This is to prevent accumulation of gases and the consequent fire hazard.

To "Unfeather" the propeller, close the throttle and turn the selector switch to "AUTOMATIC." The blades will immediately begin to decrease pitch. When the propeller R.P.M. reaches 1000, turn the ignition switch "ON", open the throttle, and re-adjust the governor control wheel as required to synchronize the R.P.M. of both engines.

Q. Sensitive Altimeter

The Kollsman Type 157-097 Sensitive Altimeter is an instrument for indicating barometric altitude above a given reference level.

The dial is marked in 100 meter divisions with the large numerals indicating each 1000 meters. Two revolutions of the long pointer will move the small pointer through 1000 meters change in altitude. The altimeter has a range of 10,000 meters. The instrument contains a barometric pressure scale from 890 to 1060 millibars, visible through a slot near the side of the dial. By turning the instrument knob, the scale rotates against a fixed reference line and the pointers of the instrument move at the same time. By subjecting the Altimeter to the barometric pressure for which it has been set, the pointers will return to zero. If the knob is rotated until the pointers indicate zero, the sub-dial will then indicate the barometric pressure at that time and place.

By adjusting the indication of the pressure scale to any given (by radio) barometric level at the point of reference, any discrepancy due to atmospheric conditions being other than standard is eliminated, and the instrument will indicate true altitude above the point of reference.

In flights of short duration, beginning and terminating at the same airport, this setting operation merely consists of adjusting the altimeter to read zero when the airplane is on the ground, so that the indications during the flight will correspond to altitude above that airport, the instrument returning to zero reading upon landing.

But in long cross-country flights the setting must be made in accordance with the pressure conditions existing at the place where the landing is to be made. Radio information concerning such conditions should be obtained preferably a short time before the landing is to take place in order to avoid the influence of possible changes of indication of the instrument. The radio information is usually broadcast without altitude correction so that by setting the altimeter in accordance with such pressure, the instrument will read zero upon landing, the indications during flight corresponding to altitude above the field and not above sea level.

R. Magnetos

Magneto switches will be tested as follows:

Modern high output aircraft engines require an effective and properly timed spark from BOTH of the spark plugs installed in each cylinder in order to properly ignite the compressed charge. The failure of one of the plugs or the ignition system supplying that plug, leaving the cylinder to operate on the remaining plug, results in faulty charge ignition characteristics and detonation. At high powers, such detonation becomes extremely serious. Proper functioning of the spark plugs and ignition system is accordingly of great importance.

Care must be exercised in the operation of ignition equipment particularly when checking the ignition system by operation on one magneto. Ground magneto tests should be conducted at 76 cm. Hg. (30") M.P. with the propeller in "LOW PITCH" position. Operation at this engine speed shall be restricted to a maximum of 30 seconds on the ground.

Operation of airplane engines on one magneto in the air (normally permissible only when checking magnetos) shall be limited to the minimum possible. Whenever an engine is operated on one magneto the power of the engine shall be reduced to "Cruising Power" before such operation in order to avoid damage to the engine from firing on only one set of spark plugs. (See "Engine Ratings" at the beginning of this Section.)

The normal drop in R.P.M. (40 to 60) when operating on one magneto varies widely among various engines, and between right and left magnetos of any engine. Engine log books should contain a statement as to the normal drop for each magneto of the particular engine as determined in the acceptance test of the engine. An increase of fifty percent over this normal drop shall be considered as an indication of excessive ignition system efficiency loss.

These limitations for operation on one magneto do not have a bearing on the operation at maximum permissible manifold pressure for short periods on the ground to check engine performance when using both magnetos. However, limiting engine temperatures shall not be exceeded.

S. Ammeter Check

With the generator line switches closed, note whether the ammeters show "charge" with the engines running at cruising speed. If so, the ammeters are satisfactory. If not, note whether the pointers appear to move freely, or if they appear to be sticking. If no charge is shown inspect for mal-function of the generator control unit. A detailed description of this unit is given in the Eclipse Instruction Book No. 1-B and its Supplements.

T. Voltmeter Check

Note the reading when the engines are running at cruising R.P.M. with the generator switches OFF. If the pointers move freely and coincide with the lines on the scales for the proper voltage setting, the functioning is satisfactory. If with the generator switches ON, the voltmeters indicate "ZERO" but the ammeters show "charge", an open circuit may be in the voltage circuit wiring or in the meters. If both voltmeter and ammeter indicate "zero" or "discharge", the generator connections should be checked for trouble. If the voltmeter indicates a low voltage, the trouble will probably be found in the voltage regulator. The pilot should not attempt to change the setting in the voltage regulator control box. Details are given in the Eclipse Instruction Book No. 1-B.

U. Operation of Two Speed Supercharger

Before starting the engines it is essential that both speed control levers be placed in the "LOW SPEED" position, that is pushed forward.

The instructions for take-off and climb are given in paragraphs "F" and "G" of this section. The engines should be operated in low blowers at low altitudes in the same manner as any normal supercharged engine fitted with a single supercharger drive gear.

The high speed supercharger ratio should be used for maximum performance during climbing or high speed level flight at altitudes above the point at which full throttle power in the low ratio coincides with rated power in the high ratio. See the altitude performance curve in W.A.C. Specification 286-Q.

The following general* information covers take-off and maximum power climb:

1. Take-off at specified R.P.M. and manifold pressure from sea level in low ratio.

2. Climb at rated R.P.M. and manifold pressure to critical altitude in low ratio. Continue climb at full throttle and rated R.P.M. to point where full throttle power in low ratio coincides with rated power in high ratio.

3. Move carburetor mixture control toward the "Full Rich" position. Change to high supercharger ratio, partially closing throttle to obtain specified manifold pressure and R.P.M. Readjust the mixture control. Continue climb at this pressure and R.P.M. to critical altitude. To maintain rated power in climb, when changing from low to high gear ratio, the supercharger gear shift and throttle should be changed simultaneously.

4. Above critical altitude full throttle will be required to obtain maximum performance.

5. Carburetor ram pressure will somewhat increase the altitudes at which the specified manifold pressure limitations will be obtained.

For cruising, the engine should be operated in the low gear ratio at all altitudes up to the altitude at which the manifold pressure will require a change to the high ratio gear.

In changing from one supercharger gear ratio to another in either direction, the engine should be partially throttled to avoid rough engagements of the clutches. Either high or low supercharger gear ratio clutches should not be engaged at intervals of less than five minutes in order to provide opportunity for dissipation of heat generated during the clutch engagement. Changing from one gear ratio to another in either direction should be done without pausing in neutral to avoid rough operation during the period of clutch engagement. During a change in ratio, a slight hesitation of the engine may be observed. This is normal for a two speed engine, and has no detrimental effect.

The carburetor mixture control should be richened before changing from the low supercharger ratio gear to the high ratio gear. After changing the supercharger ratio gear from either low to high or high to low, the mixture control should be readjusted.

The clutch control lever must be at the extremity of its travel in either gear ratio to insure complete action of the clutch control valves. Do not change from neutral to high supercharger ratio without first changing to low supercharger ratio.

*Note: For specific values relative to the operation of these engines, see paragraphs E, F and G.

V. Engine Synchroscope

This instrument is installed on the rudder support tube forward of the control column. The indicator is wired to each engine magneto switch.

When synchronizing one engine with another, the throttles are adjusted to a difference in engine speeds of roughly 150 R.P.M. At this difference in engine speeds, the needle of the Synchroscope assumes a position of approximately one-third full scale deflection with a slight trembling motion. Then, as the engines are brought closer to the same speed by further throttle adjustments, the instrument needle swings rapidly back and forth across the scale, and as the engine speed synchronism is approached and obtained this swinging motion decreases in speed and becomes motionless at some point on the scale. If the engines' speeds are synchronized to a very slight degree, the needle of the Synchroscope will slowly traverse the scale at a rate of approximately one or two oscillations per minute, depending upon the speed difference.

W. Use of Carburetor Air Preheaters

The following explanation of the carburetor preheater is approved by the Wright Aeronautical Corporation for 139-WH3 airplane engines equipped with Stromberg carburetors.

1. The function of the carburetor air preheater is to prevent the formation of ice in the carburetor and around the throttle valve. This ice formation will cut down the power developed by the engine due to restriction of the intake area. In some cases the formation of ice on the throttle valve will cause the valve to stick. The engine may also show evidence of poor distribution by smoking and rough running. There is some possibility of ice particles dislodged from the carburetor causing damage to the supercharger blower. However, the most serious effect of ice formation is loss of power resulting in extreme cases in complete stoppage of the engine.

2. Under most conditions the formation of ice is a relatively slow process and it is possible for the pilot to increase the throttle continuously by slight increments in order to maintain constant r.p.m. or manifold pressure until nearly full throttle is reached before realizing that ice is forming. This is precisely the procedure which leads to maximum ice formation and engine failure. When ice has been formed in the carburetor a forced landing is almost certain to result unless something is done immediately or unless the atmospheric conditions change radically. Since the formation of ice is dependent on the atmospheric humidity among other things, the mere act of flying into a less humid region such as leaving a cloud bank or climbing above a fog may arrest the formation. However, the ice already formed will not melt unless the entering air temperature is raised above the melting point of the ice, and the engine power will be reduced until the ice is cleared.

3. There are two general methods of using the preheater control to combat ice formation. One is to wait until ice has been formed and then supply sufficient preheat to melt the ice and thereafter maintain the carburetor intake air temperature high enough to prevent re-formation until atmospheric conditions change so as to be less favorable to ice formation. The second is to maintain the carburetor air intake temperature high enough to preclude the formation of ice under all normal conditions. Both methods have disadvantages. In the first case, it is possible to wait too long until insufficient preheat is available to melt the ice and serious reduction in power is inevitable. Furthermore, the symptoms of ice formation are not readily recognizable as such and the application of full preheat to an engine already overheated by too lean a mixture, for example, would undoubtedly cause detonation and engine failure. For the same reason continuing full preheat to the engine after the ice has melted is inadvisable. Also, heat results in detonation at a lower B.M.E.P. than is normal when the preheat is used due to an increase in average mixture temperature in the

cylinder. These higher temperatures require a fuel of greater anti-knock value to prevent detonation. The means used to regain power by this method, i.e., full throttle, full preheat to the carburetor, and full lean mixture, give the most favorable conditions for detonation; and engine detonation is probably more serious than icing of the carburetor. On the other hand, the use of the preheater to maintain the intake air above the danger point of ice formation at all times has some disadvantages. There is always the danger of inducing detonation in the high B.M.E.P. engines in service through overheating and consequent loss in effectiveness of the anti-knock qualities of the fuel. This is not so likely to occur, however, as under the first method of operation unless the pilot is careless or negligent, as for example, taking off with the preheater control set to deliver high heat to the intake air. Also, in using this method there is a definite loss of power at full throttle due to the reduced volumetric efficiency when more preheat is used than is necessary. From the above discussion, however, the latter method appears to be preferable for service use.

4. There is an average temperature drop through the carburetors of the GR-1820-G5 engines of approximately 33°C (60°F). The use of the carburetor adaptor thermometer eliminates the need for using this temperature drop through the carburetor as a means of determining icing conditions in the carburetor. For this reason carburetor adaptor temperatures above 0-1.5°C (32-35°F) will insure that ice formation will not occur in the carburetor since freezing conditions do not exist.

5. Leaning the mixture is a valuable aid in preventing ice formation, provided dangerously lean mixtures are not used, which would cause damage to the engine. Not only does leaning the mixture reduce what might be called the refrigerating capacity of the carburetor, but it also increases the average temperature of the exhaust and, hence, the amount of heat available for raising the temperature of the intake air.

6. At high altitudes the relative humidity is quite low except in clouds or storm conditions. Therefore, it does not appear essential to operate at high intake air temperatures, that is, at adaptor temperatures above freezing, except under ice forming conditions. Therefore, above fifteen thousand feet, when icing conditions do not exist, the carburetor adaptor temperature may be reduced below 1.5°C (35°F) provided the engine does not indicate improper operation.

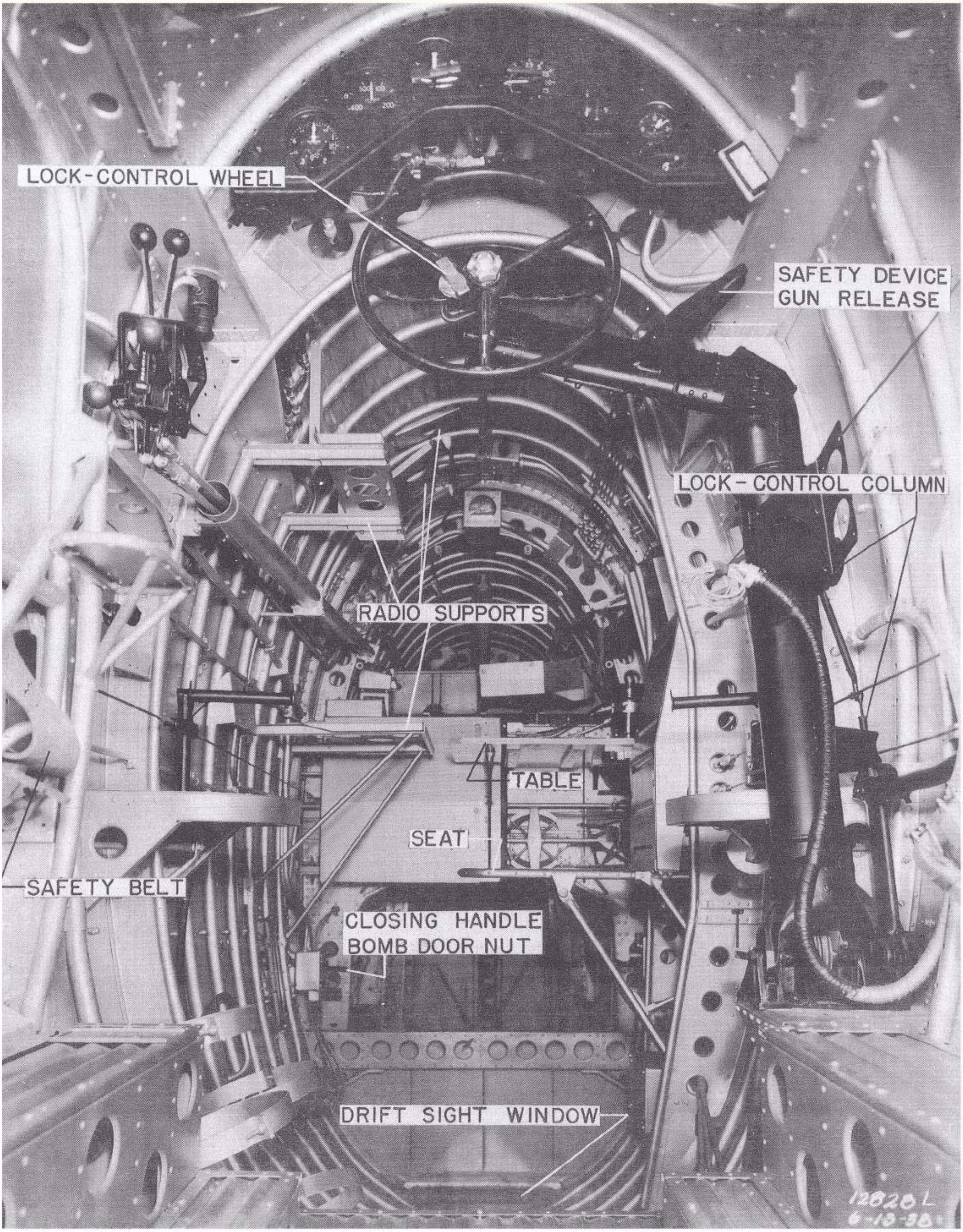


FIGURE 5A INSTRUMENTS AND CONTROLS IN CO-PILOT'S COCKPIT

C

PART 2-SECONDARY CREW MEMBERS

AA. CO-PILOT'S COCKPIT

Location of Controls

1. Rudder Pedals: located above a rigid foot rest platform at each side of the fuselage and interconnected with the pilot s rudder pedals. No adjustment is provided.

2. Elevator and Aileron Control is accomplished with a column and wheel assembly which operates the flight surfaces in the order named. These controls may be disconnected and stowed in the forward position by first pulling, then turning the latch, located near the center of the wheel; and second, turning the knob located on the right side of the column to disengage the elevator. Push the column forward, hard, into spring latch. A wedge shape bracket is clamped to the column as an assurance against fouling the column with the gun carriage in case the latter is left in the forward position, whith the controls are engaged.

3. Elevator Trim Tab is controlled by rotating the transmission shaft at the left side of the fuselage by means of the hand grip provided

4. Throttle and Mixture Control Unit located on left side of fuselage, interconnected with pilot s Unit. No supercharger regulator levers are provided. The copilot can richen the fuel mixture, but can not lean it.

Location of Equipment

1. Oxygen Controls consist of a valve located above the left rudder pedal to regulate the co-pilot's supply; a switch for operating the heater which is mounted adjacent to the regulator valve, and the supply control valves on the cylinders. A flowmeter should be installed adjacent to the pressure regulator, and a pressure gauge should be installed directly above the cylinders

2. Fire Extinguisher, a one quart Pyrene hand type is secured in a bracket located on the top left side of the fuselage below the windshield.

3. Cockpit Enclosure is a movable hood mounted on rollers and secured to tracks on each side of the fuselage. The handle provided inside on the upper left side of the hood is equipped with a latch which is operable from both sides. The hood may be locked partially open by engaging the latch in the slots provided along the track.

The rear streamline section is so constructed that it can be folded down against the top of the fuselage. This is accomplished by pulling the operating handle toward the operator. To open the section, raise the center panel with one hand and push the handle toward the rear.

4. Machine Guns. The upper rear gun is mounted on a carriage which is retained by rollers on a semi-circular track in the fuselage. A hand operated friction lock permits the carriage to be clamped at various degrees around the track. A section of the track is painted black to indicate the proper stowage position of the carriage. A friction type clip is installed on the right side of the cockpit coaming aft of the seat for holding the gun in the stowed position.

To stow the gun, latch the mounting post in the extreme right hand notch by means of latch at the base of the post. (For all normal gunnery the post may be left in this position). Move the carriage to the stowing position indicated on the track. Retract the lock at the right side of the mounting post and push the gun forward into the latch on the cockpit coaming.

Warning: Extreme care must be exercised when operating the gun not to shoot into the empennage surfaces.

The lower rear gun is mounted on a post in the bottom of the fuselage and operated through a door provided in the bottom. The door is raised by means of a latch handle and is held up by a cross bar and tension spring clips. The gun muzzle is stowed at rest in a clip located at the left side of the fuselage. Windows are provided in the fuselage opposite the bottom gun to increase visibility.

Stowage clips are provided for 12 ammunition boxes directly in front of the operator during gunnery operations.

5. Landing Flares: Two of the parachute type are carried in the flare release tubes in the rear section of the fuselage. They can be released by the pilot. The tubes are refilled by releasing the latch located between them at the top and pulling them forward. Close the bottom doors securely before refilling. Attach parachute release wire to the top cover of tube before closing and returning to original position.

6. Signal Flares*are carried on the side of the fuselage aft of the co-pilot's cockpit. The firing pistol is carried on a bracket located on the lower right longeron adjacent to the co-pilot. In discharging the pistol it is advisable to fire with the elbow cocked so the force of the recoil is absorbed by a rearward movement of the arm. Fire slightly to the rear and upward.

7. Life Raft is stowed in a bag secured to the top of the fuselage aft of the co-pilot. The bag contains two CO_2 bottles for inflating, two oars, rope, and a hand pump to maintain pressure.

8. Seat of the folding type is attached to the left side of the fuselage. A latch is installed for holding the seat in the folded condition. A step is provided on the bottom of the seat to aid ingress when the seat is folded.

9. Safety Belts: a type B-6 is provided in the fuselage for the co-pilot when he is seated. This type buckles over the co-pilot's lap A type A-3 belt is furnished for the rear gunner's safety support. This type attaches to a hanger in the floor and to the operator's harness. Normally it is removed from the airplane.

BB.Radio Operator's Compartment

Note: The airplane will be equipped with a two way communication set for telephone or telegraph, a radio compass for bearing indication and direction finding, and the five station interphone system. This equipment is manufactured by the Nederlandsche Seintoestellen Fabrick (N.S.F.) Co., Holland, who furnish complete instructions for the installation and operation.

1. Bomb Door Control is a crank handle located on the right side of the compartment aft of the rear wing spar bulkhead. The doors can be normally raised and lowered with this crank.

2. Emergency Bomb Release is a pull type handle located at the right side of the fuselage aft of the door hand crank. When pulled, it releases the bomb doors which open, then unlocks the releasable union in the fuel line for the bomb bay tank if installed, or releases the bombs in salvo.

3. Bomb Door Closing Control is a pull type handle located on the rear left side of the rear wing spar bulkhead. It is pulled while turning the bomb door crank to close the split nut on the door operating screw.

4. Oxygen Supply. A bayonet type base is provided on the left side of the fuselage. Provision is made for a pressure supply gage on the bracket with the bayonet base.

*Optional Special Equipment.

5. Seat: a folding type attached to the fuselage structure on the right of the airplane, and retained in the folded condition by a spring clip fastener.

6. Table: a folding type attached to the right side of the fuselage. It is held in the folded condition by means of a spring clip fastener.

7. Window for the drift sight is provided in the bottom of the fuselage. It can be raised for cleaning and is provided with two latches for holding it open or close

CC. Bomber and Nose Gunner's Compartment

1. Instruments installed on a panel at the left side of the fuselage nose consist of:

(a) Altimeter-Range 10,000 m., barometric pressure scale from 890 to 1060 millibars.
(b) Airspeed Indicator (0-500 km./hr.)
(c) Clock
(d) Air Temperature Indicator
(e) Compass (Magnetic) suspended from the top of the fuselage.

2. Instrument Switches. A toggle switch is provided below the instrument panel for energizing the circuit to the pilot director. A toggle switch is provided at the top of the instrument panel for operating pitot static head heater.

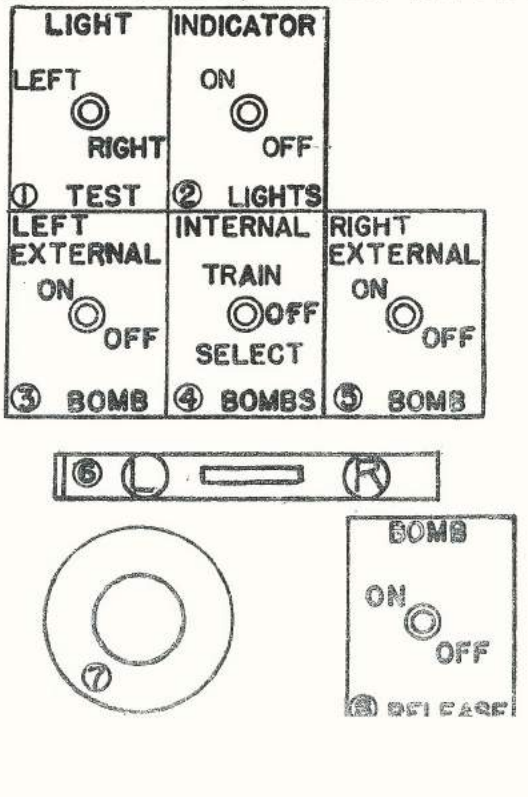
3. Bomb Release Handle located on the right side of fuselage and equipped with a spring-loaded lever for fixing the INTERNAL racks in either the "Locked", "Selective" or "Salvo" position. This release cannot be operated with the bomb doors closed. When in the "Locked" position, the electric release cannot operate.

The EXTERNAL bomb racks may be released manually in an emergency by means of the Emergency Release Handle which is located just below the machine gun turret on the right side of the fuselage. This handle is painted red.

4. Bomb Rack Locks. The internal rack release handle is safetied in the "Locked" position by means of a plunger operated by the bomb doors through a cable system. Opening the doors retracts the plunger from the release handle. The external racks are locked against inadvertent electric release by a spring loaded handle located on the right side of the fuselage aft of the red emergency release handle.

5. Arm and Safe Control Handles for both the internal and external bomb racks are located aft of the bomb release handle and are used to fix the rack mechanisms so that bombs will be released either "armed" or "safe" as desired. These controls have no effect on the actual release of bombs.

6. Bomb Release Switches are provided on the box located below the manual release handle on the right side of the fuselage. For purposes of description they are indicated here by numbers placed in the lower left hand corner.



Switch No. 1 is used to test the external bomb rack indicator lamps, (Item No. 6).
Switch No. 2 turns the external indicator lights on and off.
Switches 3, 4 and 5 are self-explaining.
Item No. 6 is slide cover for external rack indicator lights.
Switch No. 7 is a push button type used for selective release of all bombs, dependent upon which position switches 3, 4, or 5 have been placed in. For selective release, this switch must be released between the dropping of each bomb. "Train" release of the internal racks is accomplished by placing switch No. 4 in "TRAIN" position and holding down the button, (Switch No. 7) until the racks are empty.

Switch No. 8 is used to energize the circuits to the bomb rack releases. This switch must be "ON" to release any bombs electrically.

7. Bomb Sight. Provisions have been made for installing a Goerz bomb sight in the floor of this compartment.

8. Bomb Door Control Crank is located on the right side of the bomber's compartment above the entrance door. It is used for normal operation of the bomb bay doors.

9. Entrance Door to the bomber's compartment is located in the bottom of the fuselage forward of the pilot's cockpit. It may be opened from the outside by pulling down the handle, then turning; or from within the fuselage by pushing, then turning the handle.

A folding ladder which is hinged to the bulkhead aft of the door may be extended out of the airplane, or latched in a horizontal position above the door to provide a walkway to the pilot's cockpit. Normally, it should be kept folded up against the curtain thereby leaving the door opening clear for emergency exit.

10. Bomber's Seat is a folding type secured to the left side of the compartment floor. It may be pushed against the side of the fuselage during gunnery operations.

11. Nose Gun is carried on a special roller mount which is retained on a vertical track, part of the dome type turret. The dome turret is also mounted on rollers and retained on a circular track. The gun mount is equipped with latch handles which provide adjustment of the gun carriage in the up and down directions, and which permit the rotation of the complete turret through 360°. The turret may be locked in various positions throughout one complete rotation. A swinging seat is provided in the turret for the gunner. Stops on the circular track limit the rotation of the turret to prevent firing into the propellers. These stops can be lifted to permit complete rotation of the turret.

12. Oxygen Equipment consists of a pressure supply gauge and bayonet type connector located on the left side of the cockpit. The supply is controlled by the pilot.

13. Curtains are provided between the bomber's and pilot's compartments to reduce drafts. They may be locked shut on the bomber's side.

DD. Procedure for Loading and Releasing Bombs

1. General

The following loads may be carried on the internal Racks. The proper stations are shown on the racks and on the load indicator.

2 - 1130 lb. (512.5 kg.) bombs, or
3 - 625 lb. (283.5 kg.) bombs, or
5 - 300 lb. (129.3 kg.) bombs, or
9 - 122 lb. (55.3 kg.) bombs

The following load may be carried on each of the two external racks:

1 - 2000 lb. (907.0 kg.) bomb, or
1 - 1130 lb. (512.5 kg.) bomb, or
1 - 625 lb. (283.5 kg.) bomb.

Crank operated bomb hoisting drums for loading the internal racks are stowed in the top of the fuselage aft of the co-pilot. They are marked "Left" or "Right" and are installed in brackets outside the fuselage beneath the wings. Pulleys for the bomb hoist cables are provided in the top of the bomb bay.

A portable unit for loading the external racks is stowed in the tail of the airplane aft of the rear gunner's station. The internal hoist drums must be installed on this unit when it is used.

2. <u>To Load Bombs on the Internal Racks</u>

Install hoisting drums on sides of fuselage and attach proper size slings.

Place bomber's releases in "Safe" position, that is, Switches No. 4 and 8 in "OFF" position, manual control handle in "Locked" position.

Cock the stations to be loaded, using the cocking wrench which is carried on top of the longeron at the right side of the airplane.

Check indicator.

Install the shackles on the bombs.

Fix the arming wire in the shackle.

Fuse bombs in accordance with standard Service Regulations. Bombs may be fused either before or after loading on the racks, depending upon the method desired.

Hoist bombs to proper station and hook shackle to rack.

Close bomb bay doors securely.

3. <u>To Release Internal Bombs</u>

Open bomb bay doors.

Place release handle in "SELECTIVE" position.

Place "arm and safe" handle in position desired.

Place rack energizing switch (No. 8) in "ON" position.

Place switch No. 4 to "SELECT" or "TRAIN" as desired.

Release bombs in accordance with instructions given in the data accompanying the type of bomb sight used, or:

Release bombs with the push button switch (No. 7).

Caution: Always return the arming handles to the "SAFE" position except when actually bombing.

The bomber can salvo the internal bombs after opening the bomb doors by pulling the manual release handle fully back.

The pilot or the radio operator can open the bomb doors and release the internal racks by pulling the emergency release handle provided for each.

4. To Load External Bomb Rack

Assemble portable unit and internal hoisting units together and install on external rack. It is necessary to disconnect the flexible electrical conduit from the bomb rack in order to provide clearance for the bomb hoist.

Install the pulley brackets on the rack. Always check position of solenoid cocking lever for full up.

Place the external rack lock handle (located in bomber's compartment) in "SAFE" position to prevent inadvertent electrical release.

Check the return position of the emergency release cams in the pilot's cockpit by pulling the stop cables. The left cable is secured to the longeron under the cam, and the right cable is attached to an eyebolt on station 2F circumferential rib. The cables are reached from the bomb bay.

Open the bomb hooks by pulling the release rod forward and pushing the tee handle of the 600-1100 lb. cockpit rod aft.

Hoist bomb into position on proper hooks.

If 1100 or 600 lb. bombs are loaded, the large hooks for the 200 lb. bomb should not be cocked. However, the small hooks must be cocked when loading the 2000 lb. bomb.

Latch the small hooks by pushing the release rod aft and at the same time pulling on the 600-100 lb. tee handle. Next make sure the small hooks are completely closed, by moving the small latching lever located on the right side of the rack to the latched position.

When loading the 2000 lb. hooks, repeat the above procedure, then pull the 2000 lb. tee handle forward and raise the long latching lever on the right side of the rack to the latched position.

Check both levers for security before releasing the bomb support.

Install sway braces, replace electrical cable, and nose fairing; remove pulley brackets.

5. To Release External Bombs

Move lock handle to "ARM" position.

Place switch No. 8 in the "ON" position.

Place switch No. 3 or No. 5 in the "ON" position depending upon which bomb is to be released.

Release bomb with switch No. 7.

Emergency release of these racks can be accomplished by pulling the red tee handle located above the controls on the right side of the fuselage. The pilot can also release the external racks in an emergency.

EE. Flight Plan

In order that good fuel economy may be obtained in flying these airplanes, the remaining pages of this Section II-A are devoted to suggestions and performance curves which should be instructive and helpful in planning flights where fuel economy must be considered.

During operation of the airplane, fuel economy and range are directly affected by the following factors:

(a) Speed or horsepower used in flight,
(b) Altitude of flight,
(c) Gross weight of the airplane,
(d) Winds encountered,
(e) Fuel/air ratio as set by the pilot.

These factors considered in turn show that:

(a) At a definite condition of altitude, gross weight, and wind, there is one horsepower or speed at which an airplane should be flown in order to obtain the best fuel economy. This best speed (for maximum range) is shown by the curves of max. L/D on Graphs 4 to 8 inclusive.

(b) The altitude at which the airplane is flown is usually controlled by prevailing winds, weather conditions, height of mountain terrains, and tactical requirements.

(c) The gross weight of the airplane in flight is constantly changing due to the consumption of fuel and the expenditure of bomb loads. The effect of these changes in gross weight on power required and/or fuel economy is shown on the km./liter curves on Graph 3. The usual method used to calculate the varying weights of the airplane for a flight is to break up the distance of the flight into any number of sections and determine the average gross weight for each section by subtracting the weight of fuel consumed and bombs released from the weight of the airplane. Where the flight conditions (altitude, airspeed, headwinds, etc. are unchanged, two sections only are necessary. (See the accompanying problem.)

(d) Winds have a great effect on the range of an airplane, but have no effect on the amount of power for a given airspeed. The economical airspeed (airspeed for maximum range) in a headwind is slightly higher than the speed at maximum L/D (economical speed in a calm).

(e) The use of the Cambridge Mixture Indicator should enable the pilot to operate the engines with a good fuel mixture, provided the instrument is in proper adjustment. However, the amount of fuel required by any airplane when flown by different pilots will vary slightly.

To insure good fuel economy and to prevent unnecessary abuse of the engines, particular attention should be given to the R.P.M. at which a power is obtained. Flight tests have indicated that the combinations of power, R.P.M., and manifold pressures as shown on Graph 1 are approximately the best.

To assure the successful completion of a flight, it is imperative in making a flight plan to set aside a certain percent of the fuel carried as a reserve. This amount of reserve fuel will naturally vary with the accuracy of weather information, radio communication, available landing fields, etc. A minimum percent fuel reserve can be determined from flight practice in the locality of operations.

In general, practice missions will not be performed on which the flight must be made at speeds of maximum L/D. However, many flights are of such range that it is necessary to determine the limiting speed or power which may be used in the flight in order to assure successful completion with the amount of fuel carried on board the airplane.

In order to more clearly describe the use of the accompanying curves in laying out a flight plan, a typical problem is given below using one method for solving. It should be understood that the method used is not intended to dictate the only method by which all similar problems can be solved.

Problem

It is desired to fly with 1000 kg. of bombs, carried on the internal rack, to an objective 1100 kilometers away where the bombs are to be dropped. The airplane is to return to the original airport. The following conditions are known to exist:

1. Radio communication with home airport only.

2. The prevailing wind at 4000 meters altitude will be an average 30 km./hr. tail wind while flying toward the objective. Below 3000 meters the wind will be generally a cross wind of unknown velocity while flying both to and from the objective.

3. The only landing field to be considered is the home airport.

4. Amount of fuel on board. . . . . .1953 liters
   20% of fuel as reserve . . . . 390 liters
   Fuel to be consumed in flight. . . . . .1562 liters
   Gross weight at start. . . . . .7800 kg.
   Gross weight, end of flight (less fuel and oil consumed and bombs dropped) approximately . . . . .5680 kg.

Solution

Reduce the 2200 kilometer (both directions) flight into four sections of 550 kilometers each. To calculate the average gross weight of each section, assume that the fuel will be consumed equally in each section at the rate of 280 kg. each section. Therefore, at the end of the first section flown, the gross weight is reduced to 7520 kg., and the average gross weight is 7660 kg. Similarly, the average gross weights for sections 2, 3, and 4 are calculated as shown in the following list which includes the first section.

Average gross weight - 1st section. . . . .7660 kg.
Average gross weight - 2nd section. . . . .7380 kg.
(Bombs dropped)
Average gross weight - 3rd section. . . . .6100 kg.
Average gross weight - 4th section. . . . .5820 kg.

The flight plan will specify that the flight out be made at 4000 meters altitude, and the flight back at 3000 meters altitude. *See note below.

The kilometers per liter at 400 B.H.P. at 4000 meters altitude should now be determined for the first and second sections, using the average gross weight of these sections. Since the wind velocity at 4000 meters altitude is known, these values of km./liter should be corrected as shown in the following example.

*NOTE: It will be noticed on the following chart that the plan calls for the third section to be flown at 400 H.P. This is done because there is ample fuel supply, and it was felt that perhaps the pilot would prefer to leave the vicinity of the objective as rapidly as possible.

Corrected km./liter = $\frac{\text{(Uncorrected km./liter)(Ground Speed)}}{\text{Air Speed}}$

The airspeed is obtainable from Graph 8.
For Section I (Gross Weight = 7660 kg.)
Corrected km./liter = $\frac{1.32 \times 312}{282}$ = 1.46 km./liter

This procedure should be followed through for each section, but of course, the values of km./liter for Sections 3 and 4 on the return flight will be taken directly from the curves on Graph 3 as the wind condition is not known.

When complete data are obtained, the information should be put into a comprehensible flight plan for the pilot similar to the following:

FLIGHT PLAN

Section No.	Av. Gross Wt. Kg.	H.P. Per Eng.	Alt. Meter	Time Hrs.	Total Time Hrs.	Dist. (Km.)	*Air-speed Km./Hr.	Ground Speed Km./Hr.	Km./ Liter	Fuel Liter	Total Fuel Liters
1	7660	400	4000	1.78	1.78	550	282	312	1.46	380	380
2	7380	400	4000	1.74	3.52	550	287	317	1.49	372	752
3	6100	400	3000	1.90	5.42	550	291	291	1.35	412	1164
4	5820	300	3000	2.15	7.57	550	257	257	1.52	367	1531

Note: If, for any reason, the objective is not reached on schedule, reduce the power in the third section to 300 H.P.

*The airspeeds shown are true airspeeds and should be reduced to indicated airspeeds for each altitude and for each particular airplane airspeed-meter installation.

IMPORTANT NOTE: THIS TYPICAL FLIGHT PLAN, AND GRAPHS NO. 1 AND NO. 2, ARE BASED ON LOW GEAR BLOWER OPERATION FOR GREATEST FUEL ECONOMY. USE OF HIGH GEAR BLOWER INCREASES FUEL CONSUMPTION APPROXIMATELY 25%.

PILOT'S READY REFERENCE CHART
GR-1820-G5 Engines (W.A.C. Spec. 286-Q)

INSTRUMENT READINGS

Cyl. Head Temp.- Max. (15 Min. Duration)	500°F (260°C)
Cyl. Head Temp.- Max. (Continuous Operation)	400°F (205°C)
Cyl. Head Temp.- Max. (Cruising)	370°F (188°C)
Oil Temp. - Desired	140°F (60°C)
Oil Temp. - Max.	210°F (88°C)
Oil Press.	50 to 65 lb./sq.in. (3.51-4.52 kg./Cm²)
Fuel Press.	3.5 to 4 lb./sq.in. (.21-.28 kg./Cm²)
Vacuum	3 to 5 in. Mercury (76.2-127.0 Mm)
Gyro Pilot Oil Press.	(Approx.) 75 lb./sq. in. (5.27 kg./Cm²)

ENGINE OPERATION (Subject to ±2½% Variation	H.P.	RPM.	M.P. Cm. Hg.	M.P. In. Hg.	Super Gear Ratio
Emergency and Takeoff	950	2200	100.3	39.5	7.14:1
Rated Power (S.L.)	850	2100	90.6	35.7	7.14:1
Rated Power 1st Crit. Alt. 6000 ft (1828 m)	850	2100	86.3	34.0	7.14:1
Rated Power 2nd Crit. Alt.15200 ft.(4132.9m)	750	2100	85.9	33.5	10.0:1
Max. Cruising Limits	600	1900			
Recommended Cruising Limits	500	1850	-----	-----	

TAKE-OFF CHECK

Cowl Flaps- - - - - - - - - - - - - - - - - - -CLOSED
Wing Flaps- - - - - - - - - - - - - - - - - UP NORMALLY
Propeller Governors (2200 RPM)- - - - - LOW PITCH
Control Tabs- - - - - - - - - - - - - - - - - NEUTRAL
Mixture Controls- - - - - - - - - - - - - FULL RICH
Cross Feed Valve- - - - - - - - - - - - - - - - - -ON

LANDING CHECK

Landing Gear- - - - - - - - - - - - - - - - - - - -DOWN
Propeller Governors (2100-2200 RPM) - - LOW PITCH
Mixture Controls- - - - - - - - - - - - - FULL RICH
Supercharger Speed Control- - - - - - - LOW SPEED
Supercharger Regulator- - - - - - - - -HIGH BOOST

Range and Endurance for 100 liters of fuel at a gross weight of 7500 kg.:

BHP/Eng. (English)	Alt. (Meters)	True Air-speed (Km/hr.)	Ind. Air-speed (Km/hr.)	Range (Km.)	Approx. Time (Hrs.)
600	S.L.	303	303	85.0	.28
600	1000	314	299	87.9	.28
600	2000	325	294	90.7	.28
600	3000	337	290	93.7	.28
500	S.L.	282	282	101.5	.36
500	1000	292	277	105.0	.36
500	2000	301	272	108.5	.36
500	3000	309	267	111.4	.36
500	4000	320	261	116.7	.37
400	S.L.	258	258	118.3	.46
400	1000	264	251	121.7	.46
400	2000	272	246	125.2	.46
400	3000	278	241	128.2	.46
400	4000	285	233	134.6	.47
300	S.L.	219	219	127.8	.58
300	1000	224	212	129.9	.58
300	2000	228	208	133.9	.59
300	3000	232	201	136.9	.59
300	4000	233	191	141.5	.61

Range and Endurance for 100 liters of fuel at 300 H.P. and a gross wt. of 5500 kg.:

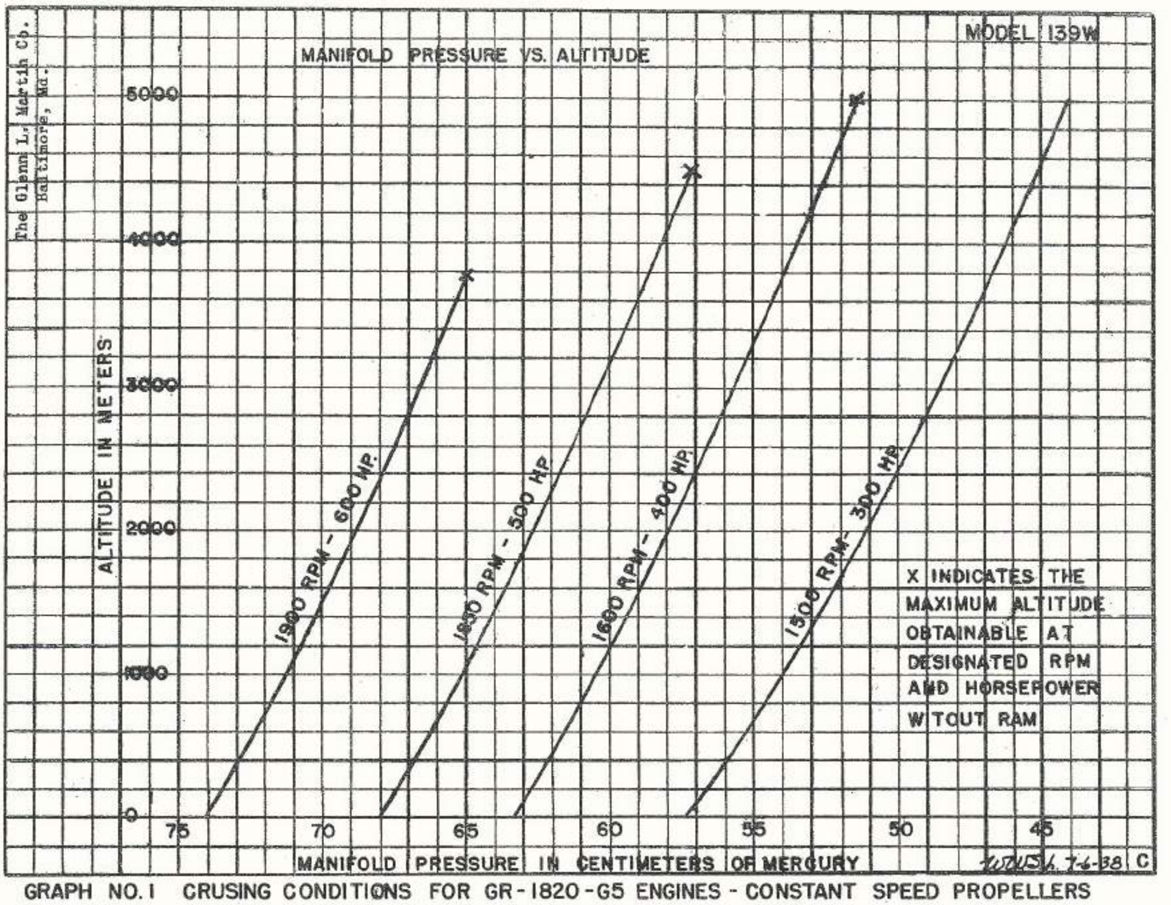
300	S.L.	237	237	138.2	.58
300	1000	245	233	142.0	.58
300	2000	253	228	148.0	.59
300	3000	259	224	153.2	.59
300	4000	266	217	161.4	.61

Range increases with lighter gross weights, and decreases with greater gross weight. To correct range for wind, multiply actual ground speed by endurance in hours.

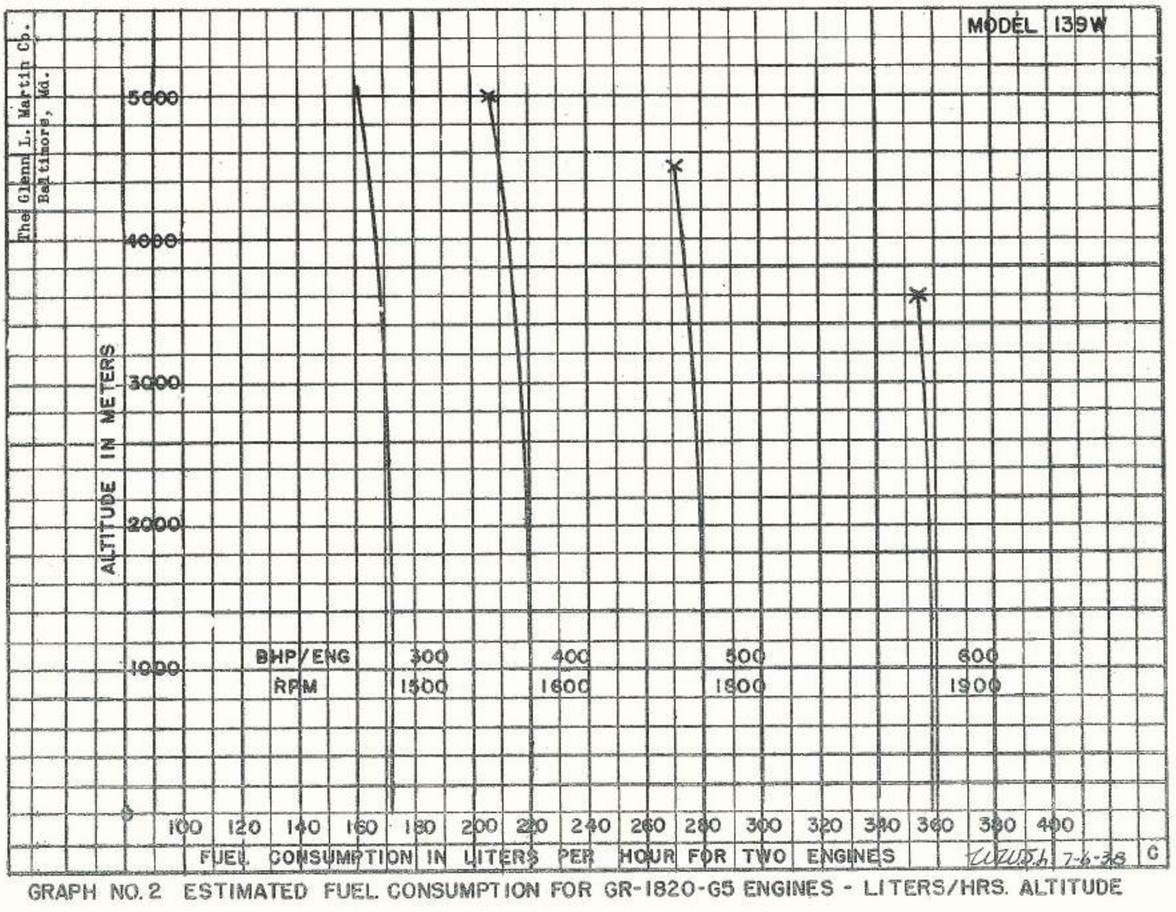
Note: The above indicated airspeeds should be calibrated for installation and instrument errors for each airplane

WARNINGS

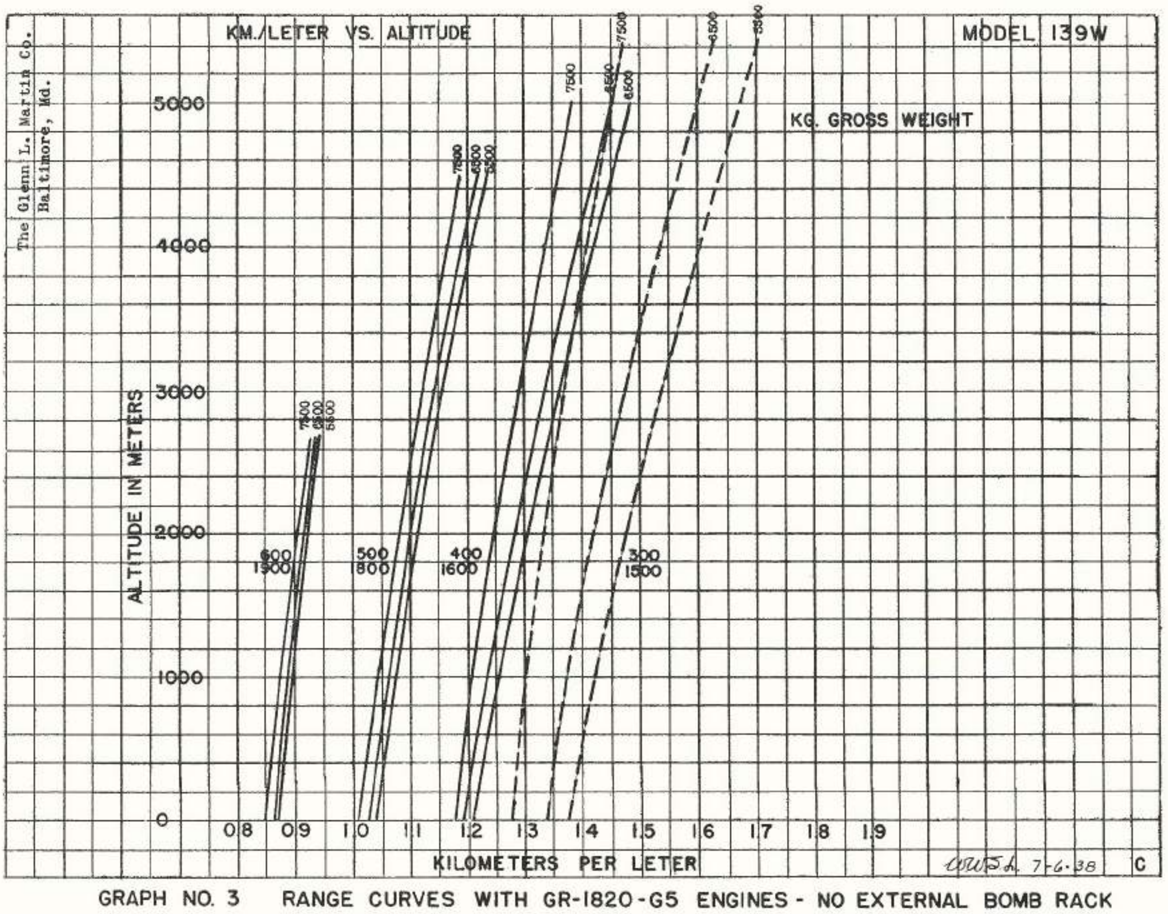
1. Cowl flaps must be open for all ground operation of engines.
2. Start engines with prop. in low pitch and warm engines up with propellers in low pitch.
3. Keep Cambridge Mixture Indicator turned "On" at all times while engines are running.
4. Do not lower flaps at an airspeed above 209 kilometers per hour.
5. Do not dive airplane faster than 400 km./hr.
6. Do not perform any of the following maneuvers: Spins, Rolls, Immelmanns, Inverted Flight, Loops, or Fast Dives.
7. Start engines with supercharger speed control in "Low Speed" position.



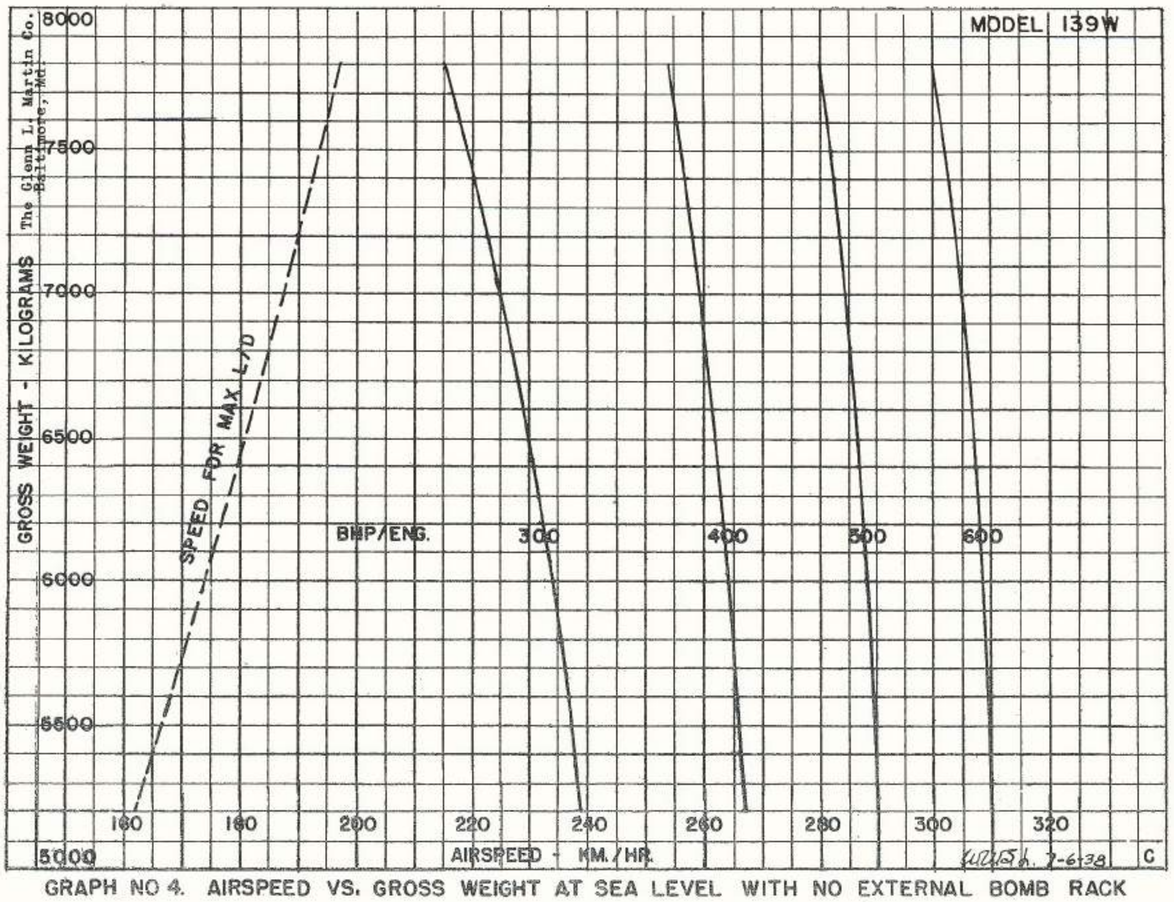
GRAPH NO. 1 CRUSING CONDITIONS FOR GR-1820-G5 ENGINES - CONSTANT SPEED PROPELLERS



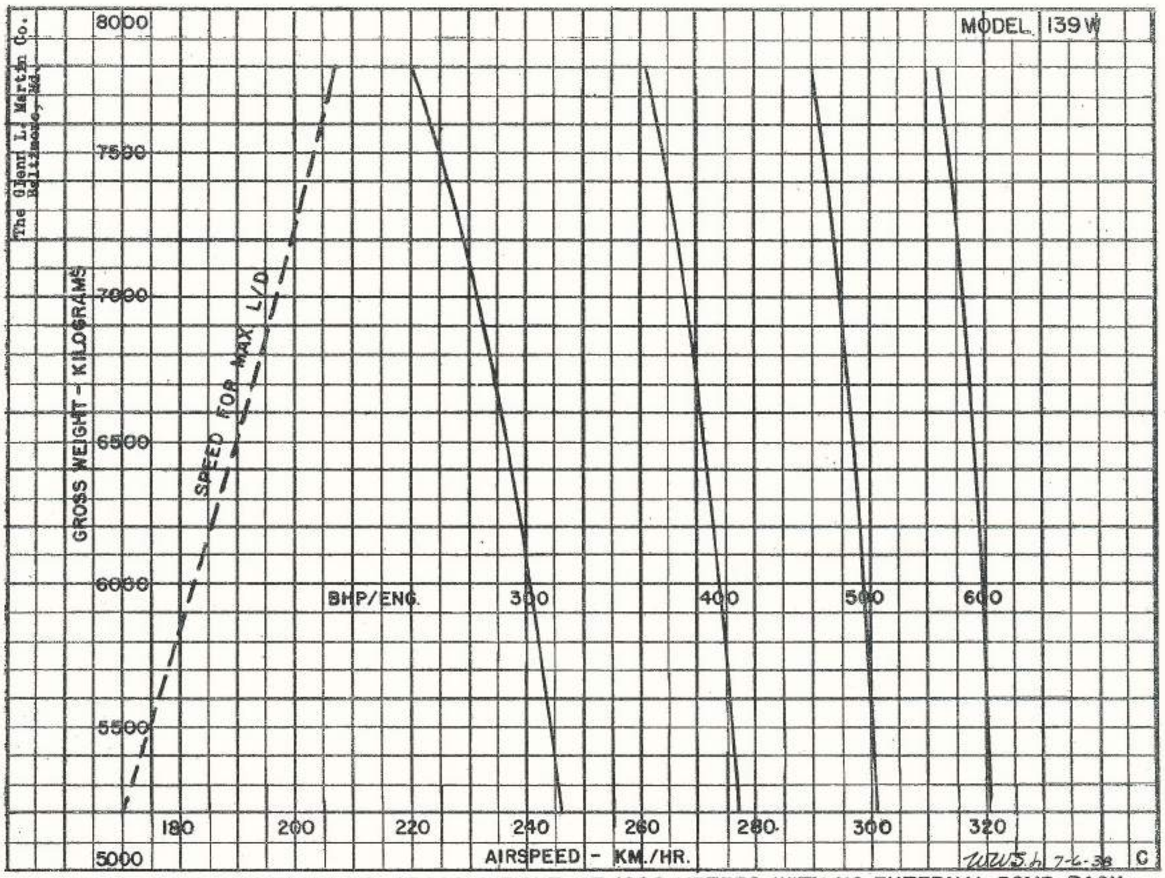
GRAPH NO. 2 ESTIMATED FUEL CONSUMPTION FOR GR-1820-G5 ENGINES - LITERS/HRS. ALTITUDE



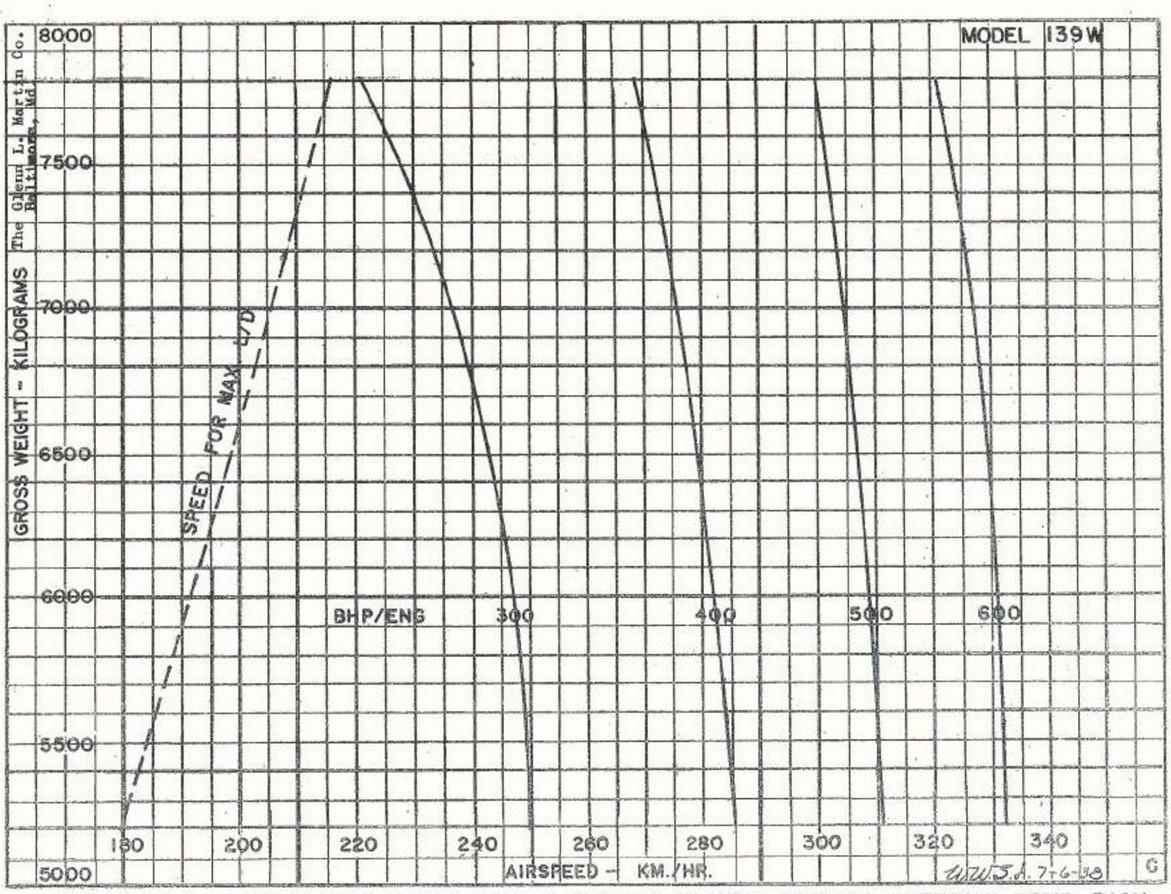
GRAPH NO. 3 RANGE CURVES WITH GR-1820-G5 ENGINES - NO EXTERNAL BOMB RACK



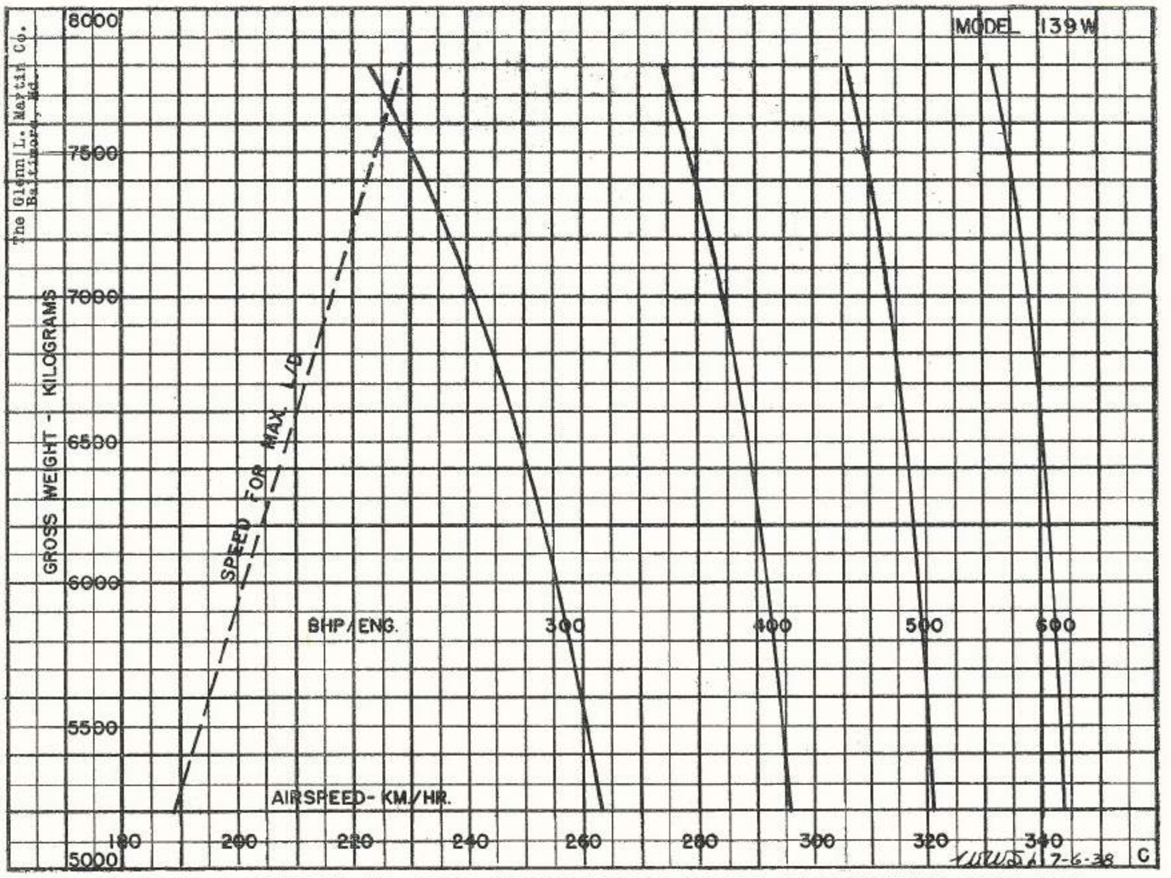
GRAPH NO 4. AIRSPEED VS. GROSS WEIGHT AT SEA LEVEL WITH NO EXTERNAL BOMB RACK



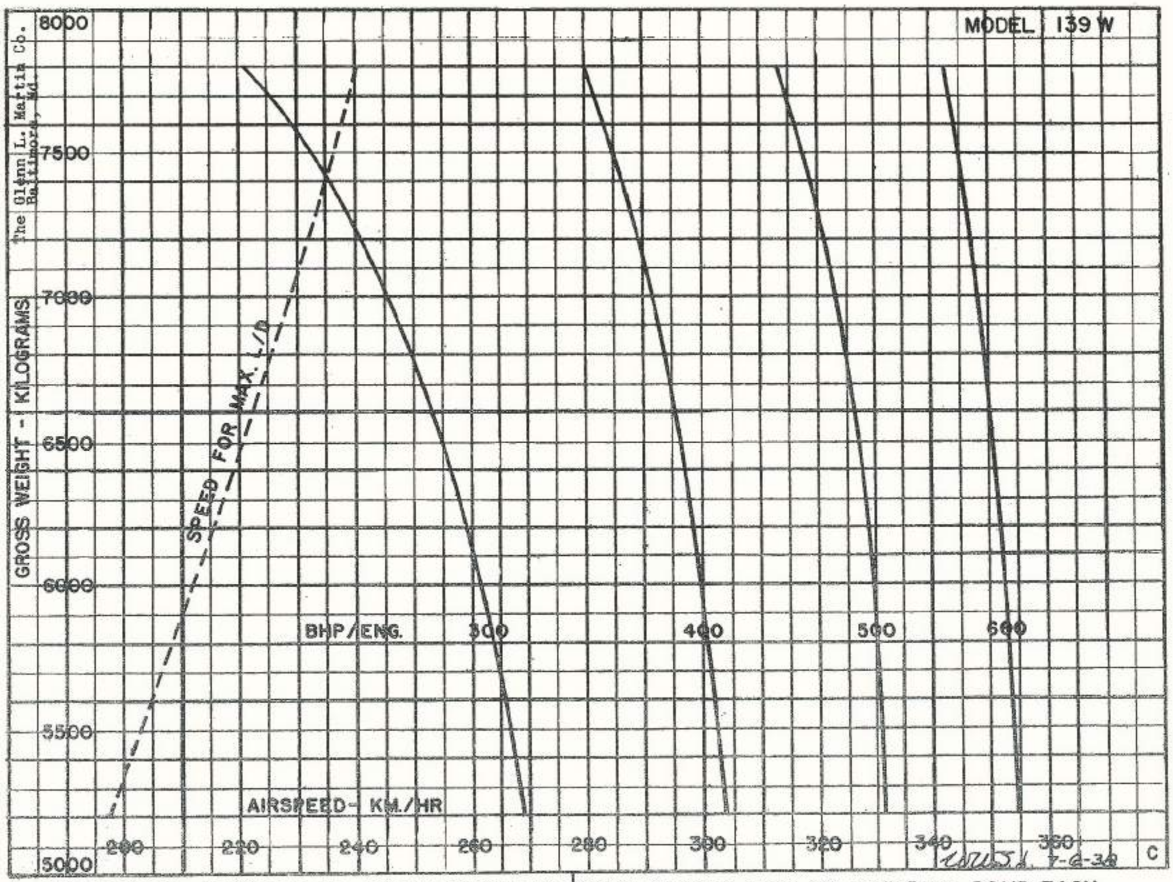
GRAPH NO.5 AIRSPEED VS. GROSS WEIGHT AT 1000 METERS WITH NO EXTERNAL BOMB RACK



GRAPH NO. 6 AIRSPEED VS. GROSS WEIGHT AT 2000 METERS WITH NO EXTERNAL BOMB RACK



GRAPH NO. 7 AIRSPEED VS. GROSS WEIGHT AT 3000 METERS WITH EXTERNAL BOMB RACK



GRAPH NO. 8 AIRSPEED VS. GROSS WEIGHT AT 4000 METERS WITH NO EXTERNAL BOMB RACK

Section II-B

Protective Coatings and Finishes

A. Anodic Treatment

The protection of the structural parts of these airplanes from corrosion; and also the paint finishes applied thereon, are in accordance with the standard methods and approved processes.

In general, all aluminum, and aluminum alloy parts, except as noted below, are given the anodic treatment in detail, after cleaning and prior to application of Zinc Chromate primer. The following parts have not been anodized:

(a) Aluminum alloy castings
(b) Aluminum and Alclad aluminum alloy parts for fuel and oil tanks
(c) Aluminum alloy fuel and oil lines
(d) Aluminum alloy forgings with a diameter or thickness greater than 1/8 inch
(e) Aluminum and/or aluminum alloy conduit for electric wiring and control cables.

B. Cadmium Plating

In general, all steel parts including washers and iron rivets, are cadmium plated by electrolysis. No plating has been given the following parts:

(a) Parts manufactured from corrosion-resistant or stainless steel
(b) Large welded structures, such as engine mounts
(c) Cables and springs. (Except as specified on drawings.)
(d) Members or parts of members which act as bearings or journals.
(e) Spring steel lock washers.

C. Paint Surfacing

In general, all parts have been painted in detail with the specified priming coat or coats, sprayed or dipped on immediately after the anodic treatment, or after plating or cleaning, but before assembly. After assembly, additional coats of paint have been applied as specified. Parts or surfaces not easily accessible after assembly are given one or more coats of the specified final finish prior to assembly.

The final finish is a "Dulux" enamel, a product of the E.I. Du Pont de Nemours and Company, Philadelphia, Pennsylvania. This finish should be allowed to harden for approximately 60 days after delivery of the airplanes before it is polished or waxed. In the meantime, it will maintain its new appearance, color and gloss if it is washed with fresh water and mild soap solution when necessary. One of the two methods of finish preservation noted below should be followed after the time noted above has elapsed.

1. Use a combination cleaner and polisher such as #7 Duco Polish "Speed Blend" as required. (du Pont Product.)

2. First clean, then wax the enameled surfaces, using materials such as du Pont Cleaner and Duco Wax.

Note: The second method requires more time, but it offers more protection to the enamel from dust and the ultra-violet rays of the sun.

3. The shades of enamel and pigmented dope employed on these airplanes are as near as possible to the shades represented by the following commercial indices:

List of Finish Shades & Specifications

Light Blue Enamel	duPont	83-5293
Yellow Enamel	duPont	83-5288
Insignia White Enamel	duPont	83-508
Insignia Blue Enamel	duPont	83-5290
Insignia Red Enamel	duPont	83-5289
Insignia International Orange Enamel	duPont	83-5400
Insignia Black Enamel	duPont	83-005
*Aluminum Lacquer	duPont	#1913
	Albron	#325 (Pigment)
Yellow Semi-Pigmented Dope	duPont	J-906319
White Pigmented Dope	duPont	J-895348
Blue Pigmented Dope	duPont	J-895346
Red Pigmented Dope	duPont	J-895347
Dull Black Lacquer	duPont	J-92-6406
Zinc Chromate Primer	duPont	P-27a

*NOTE: Aluminum Lacquer is made up on the job (at time needed) by mixing either 8 ounces Albron 325 mesh Powder, or 12 ounces Albron 325 mesh Paste, with each gallon of varnish specified. Albron powder and paste is made by the Aluminum Co. of America.

D. Finishes

** The interior surfaces of the wings and tail surfaces are painted with one coat each of zinc chromate primer and one coat of aluminized zinc chromate primer.

The interior surface of the fuselage is painted with zinc chromate primer and aluminum lacquer.

The exterior surfaces of the fuselage, landing gear, and engine nacelles are painted with zinc chromate primer and light blue enamel.

Note 1: The exterior surfaces of the wings and tail surfaces are painted with zinc chromate primer and yellow enamel.

Note 2: The fabric covered portions on the wing and tail surfaces (except the rudder) are coated with yellow semi-pigmented nitrate dope.

The rudder is painted with three horizontal stripes of equal width. The top stripe is red, the center stripe white, and the lower stripe is blue.

**Aluminized zinc chromate primer is mixed using 4 oz. 325 mesh aluminum powder per gallon of zinc chromate primer.

Alclad parts are painted only when it is necessary that the appearance of adjacent parts should match.

E. Piping Identification

The following colors and color combinations (bands) are painted on the various piping systems to readily identify them.

Fuel	Red
Oil (lubricating)	Yellow
Fire Extinguisher	Brown
Flotation Equipment	Light Blue
Oxygen	Light Green
Airspeed	Black
Manifold Pressure	White & Light Blue
Vacuum	White & Light Green
Exhaust Analyzer	Light Blue & Brown
Flap Lines	Yellow & Gray
Gyro Pilot Oil Lines	Yellow & Black
Brake Lines	Light Blue & Yellow
Compressed Air Lines	Light Blue & Light Green

F. Painting Instructions

The following instructions are recommended for retouching paint finishes.

1. Area to be retouched should be thoroughly "de-waxed."

This should be done to a distance of approximately 12 in. (30 cm.) around the area to be retouched. Any wax remaining will cause finish to peel. De-waxing may be done as follows:

a. Wash area with a mixture of 50% kerosene and 50% water and wipe dry.

b. Wash with a solution of water and mild soap.

2. Where finish has peeled or flaked, loose paint should be peeled off, and edges tapered by rubbing with fine sandpaper such as No. 320.

3. Surface around de-waxed area should be masked to prevent settling of flying paint particles.

4. Spray peeled or flaked area with light coat of Zinc Chromate Primer. (A light coat is better than a heavy one.)

5. Lightly rub primer with sandpaper when dry, and wipe with clean cloth. Allow 4 hours drying of primer.

6. Spray finish coat on, taking care not to spray up to masking material, as this will result in a ridge.

7. Remove masking as soon as final coat is sprayed. Leaving masking tape on a light-colored finish for any considerable length of time may result in discoloration.

Paints for retouching will give the best results when thinned as follows:

a. Enamels---use 10% thinner.

b. Lacquers---use 30% thinner.

Aluminum enamels and lacquers must be mixed fresh each time used, as the aluminum powder will absorb the varnish or lacquer and not leaf properly if mixed more than 5 or 6 hours before using. The proper proportions for mixing are: 8 oz. #325 mesh aluminum powder (or 12 oz. of aluminum paste) per gallon of unthinned varnish or clear lacquer.

"Blending" of the retouched areas may be done by lightly rubbing the retouched area with rubbing compound. Care should be exercised not to rub through the finish; and 48 hours drying of finish should be allowed before blending. Blending should be followed with a wax coat.

SECTION III

GENERAL INSTRUCTIONS

A. Ground Anchorage

When the airplane is to be left outside for some time, it should be headed down wind, and the control surfaces locked in the pilot's cockpit. A strap is provided on the rudder cross tube for locking the aileron and elevator controls forward. This strap should be wrapped around one spoke of the control wheel, and then passed forward around the control column to the cross tube, and the buckle drawn tight in order to eliminate whipping of the surfaces. By pushing the right rudder pedal forward, the rudder controls may be locked by means of a lockpin on the right rear corner of the pilot's floor. The airplane may then be staked down from three points, mooring lines being fastened to the loop forward of the tail wheel, and to the two fittings on the outer wing panels under the front beam. If the airplane is left out of doors in extremely high winds, it is advisable to install padded safety boards across the tail surfaces as shown in Figure 5-B. These boards should be used in lieu of the devices previously described any time high winds are expected.

B. Towing

Towing fittings consisting of an eyebolt and shackle are provided on the landing gear fork struts. The airplane may also be towed from the salvage loop located just in front of the tail wheel, but care should be taken that the tail wheel or the rear fuselage fairing is not damaged by the towing lines.

C. Lifting

The fuselage tail can be lifted by passing a tube through the fuselage at a point just in front of the stabilizer. The tail can then be lifted by personnel, or by a chain hoist.

CAUTION: The lifting tube, or bar should be passed completely through the fuselage, because the fixed tube in the fuselage is of light gauge aluminum alloy and may be easily damaged if the hoist bar is passed only partly through, and the fuselage lifted from only one side.

D. Access Doors

Inspection and access doors, which are secured with screws, are provided at different places in the wings for inspection, or removal of certain items. Since they constitute an important part of the primary structure, they must be carefully replaced.

Important: Screws of two different lengths have been used to secure the tank doors in the center wing; the longer ones, A-4619-10-16 are used to attach the doors along the front and rear spars, and the shorter ones, A-4619-10-12, are used at all other points of attachment. Care should be exercised when replacing these doors to ascertain that the proper length screws are used at the various places. The wing gap cover screws are the same as the short length tank door screws. The nuts on the bolts which attach the fuel pump bracket are accessible through the landing gear wheel well.

E. Anchor Elastic Stop Nuts

The Elastic Stop Nuts inside the wing on all access doors may become so tight as to damage the slots in the screw heads unless lubricant is put on the threads before inserting the screws in the nuts It is also very important that a large screw-driver of the proper size be used on these screws in order not to injure the slot. A tightener may be secured from the Elastic Stop Nut Corporation.

The use of Elastic Stop Nuts is permitted for assembling together sections of the main fuselage structure, and for attaching brackets, fairleads, clamps, and other miscellaneous items when the attaching bolts are in shear. These nuts are not to be used where the attaching bolts are in tension

Do not use an Elastic Stop Nut if it appears loose. Normally, they cannot be used more than three times as the efficiency of the fibre filler is reduced each time the nut is removed

F. Hoisting

Provisions are made on the front wing spar at the engine nacelle for hoisting the airplane while the tail is on the ground These fittings are accessible by removing the upper section of the nacelle cowling

CAUTION: These fittings are designed for hoisting the airplane with the tail on the ground, primarily for checking the operation of the landing gear If the tail is raised until the airplane is level, the hoist chain may damage the fixed section of cowling attached to the wing just behind the hoist fittings. If it is desired to level the airplane, see Paragraph G

The outer wing panel, when detached from the wing stub, may be hoisted with a sling attached to two eye-bolts which must be screwed into fittings provided on the front and rear wing spars at Station No 17 (approximate center of gravity). The eye bolts, No AN 46-4, are stowed in the bag containing the wing wrenches. The attaching holes should be kept closed with the special screws, No. A-115671, when the airplane is in service IMPORTANT: THESE FITTINGS SHOULD NEVER BE USED FOR HOISTING THE COMPLETE AIRPLANE.

G Leveling

Lugs are provided on the wings and fuselage for leveling the airplane both laterally, and fore and aft The lateral leveling lugs are located on the under side of the rear wing spar on the right side of the fuselage These points are marked on the lower surface of the wing. Fore and aft leveling lugs are located on the right side of the fuselage beneath the wing, and are parallel to the thrust line of the airplane. When leveling the airplane, the tail should be raised slightly above the level position and the salvage loop blocked up, and then tied down securely in this position To obtain level longitudinally and laterally, jacks should be used at the jack pads under the front spar.

H. Jacking Up the Airplane

Jacking pads are provided on the under side of the front wing spar at the wing hinge connections for lifting the airplane. Care should be taken that the jacks do not slip off these fittings and damage the wing. It is important that the tail always be held securely when jacking up the airplane.

I. Walkways

The wings should not be walked on except where rubber walkways are provided adjacent to the fuselage, or where the wings are painted black around the nacelle fairing. Other parts of the center section wings can be walked on if heavy stiffener pads or padded boards are provided for protection.

A passageway is provided through the airplane from the front gunner's station to the rear gunner's station. In the bomber's compartment, passage over the exit door is accomplished with a folding ladder normally stowed against the bulkhead curtain, but which can be latched across the door opening. Do not step on the exit doors as they will not support a heavy weight. Passage through the cockpit is below the pilot's seat. The bomb bay doors are reinforced to permit walking on them. Crew members should take hand support from the fixed structure when walking on these doors in flight as an added precaution against their opening.

When the airplane is without bomb load or auxiliary fuel tank any member of the crew can change places with any other member. When bombs or auxiliary fuel tank are carried in the internal bomb bay, the front gunner and the pilot can interchange positions, or the radio operator and the rear gunner can interchange positions. In case the pilot is disabled the front gunner can, by hinging down the bottom of the pilot's seat, lower the pilot to the bottom of the fuselage and take his place at the controls. In an emergency, if bombs are carried, they may be released and the pilot can pass through the bomb bay to the rear or a rear man pass forward to take the pilot's place.

J. Lubricants and Special Compounds

1. Threads

In many cases throughout the airplane both male and female pipe fittings are provided in aluminum alloy. Extreme care must be used in assembling these fittings as the threads must be thoroughly coated with a satisfactory thread-lubricating compound to prevent their seizing and tearing loose. A supply of Parker Threadlube is furnished with each airplane to be used in making such assemblies and repairs.

The threads and shanks of all main steel bolts and pins used for the installation of the landing gear, tail wheel, and engine mounts, and on the attaching bolts used when installing the wings, empennage, and flight control surfaces, should be given a thin coating of "Graphite Compound-Van Estan number 3", a supply of which is also furnished with each airplane.

2. Fittings, Mechanisms, Etc.

Lubrication of the various mechanisms in this airplane as indicated on the diagrams, Figures 13, 30, 56 and 65, is given in general accordance with the U.S. Army Specifications. The listed materials are considered by this Company to be closely equivalent to the given Spec. numbers.

(See Appendix IV for tabulated list.)

K. Reflectors

Silver-surfaced light reflectors should be polished when they become dull by first cleaning with fresh water and absorbent cotton, and then rubbing lightly with absorbent cotton soaked in a good grade of Silver Polish. (See list in Appendix IV.) Following this, they should be cleaned off with Carbon Tetrachloride, and then finally polished with dry cotton. Note: Do no use rouge or scouring powder. The silver coating is only about .00004 inch thick, and is easily scratched through.

L. Tables and Charts

A list of Standard Tolerances covering bolts, bearing fittings, and controls is given in Appendix V at the end of this Manual. An English Metric conversion table is also given in Appendix V for convenience.

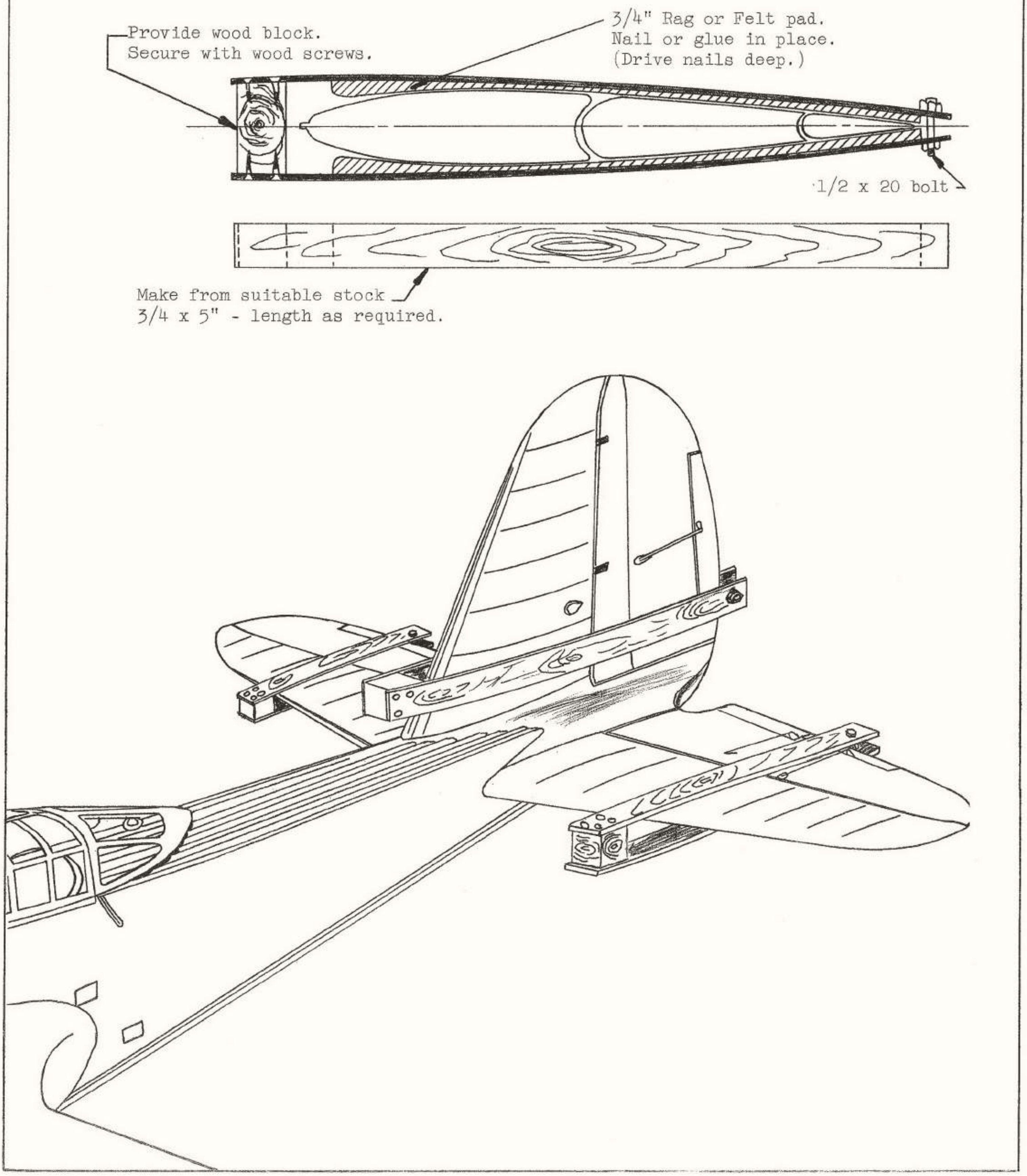


FIGURE 5B METHOD FOR SECURING TAIL SURFACES DURING HIGH GROUND WINDS

Section IV

Wings

A. Description

The wings are of the cantilever type comprising a center section, (Fig. 7), and two detachable outer panels, (Figs. 6 and 11). The wings are constructed on the box type principle consisting of two tension field web beams with truss type ribs or bulkheads between. The ribs support a corrugated top reinforcing sheet, and a reinforced bottom sheet between the beams. The wing nose section and rear trailing section structure consists of closely spaced metal ribs formed or trussed and riveted to the beams, and covered with a thin metal skin. The corrugated sheet between the beams is also covered with a smooth metal skin riveted to each corrugation and to tie plates provided on the beam chords.

The entire structure is fabricated from aluminum alloy except where high stresses and tension justify the use of heat treated chrome-molybdenum steel. All parts of the wings which are subjected to such stresses are bolted to the structure.

The box beam portion of the center wing is built semi-integrally with the center portion of the fuselage. There is no means of detaching the center wing from the fuselage. (See Fig. 7.) Provision is made in the section for installing two fuel tanks in each side of the wing outboard of the fuselage. Large removable access doors are provided in the bottom covering to permit installation and removal of these tanks. The panels are a structural part of the wing and the airplane should never be flown when they are removed.

A recess is also provided in the bottom of the wing in which the landing wheels are housed when retracted. Two oil tanks are installed in cradles provided on the rear side of the front beam and are put in place through the wheel wells.

The outer wing panels are tapered in both plan and section. (See Fig. 6.) These panels are attached to the center section by means of steel hinge fittings provided at the ends of the lower beam chords and by means of bolts through the spar webbs. Elastic stop nuts are used on these bolts. See Fig. 12 for these assemblies. The gap between the wing sections is covered by a heavy strip of metal on the bottom between the beams which providés structural rigidity in that section. These gap strips must be installed before the airplane is flown. The assembly of the remaining gap covers is shown in Fig. 12. The corrugated portions of the center and outer wings are bolted together with $\frac{1}{4}$" diameter bolts at every corrugated valley, the bolts passing through channels which are riveted to the corrugated sheet. The edges of these members must butt together and be a good fit in order to transfer compression loads.

B. Flotation Compartments

The nose section of the outer wings between Stations 10B and 15C is constructed watertight to provide emergency flotation compartments in case of a forced landing in water. These compartments are vented by means of two pipe lines which are supported by clamps on the front wing beam and which terminate in the pilot's cockpit. IMPORTANT: These vent lines must be kept clean and free from dirt and the screens provided at the ends of the tubes in the fuselage must not be allowed to become clogged. If stoppage of these lines occurs a pressure differential between the inside and outside of the watertight compartments will be built up as the plane ascends and damage to the wing structure may result.

Rubber hose connections between the outer and center wing panel vent tubes are accessible through the wing gap, one being in front of the beam and the other just behind the front beam. Drain plugs are located at the lowest point in each compartment and they should be removed every thirty days to allow condensed moisture to drain out. Four bilge pump connections have been provided in the flotation compartment vent lines at the upper longerons, two on each side of the pilot's cockpit. Access to the 3/4" female pipe threads provided for the pump connection is obtained by removing the knurled screen retainer nuts from the top of the vent lines.

C. Assembly

The aileron control cables, aileron tab cables, and flap control rod should be installed in the outer panel before assembly to the center section, and the ends of the cables should be slipped through the outer box rib of the center section as the outer panel is brought into position. A tool bag containing wing wrenches is supplied. There are six socket ends, five wrenches and two socket wrench handles bearing the following part numbers:

Wrenches	Wrench Handles	Socket Ends
2--A--108602	1--A-108603	2--A-108605
1--A--126069	1--A-108604	2--A-108606
1--A--126068		2--A-108607
1--A--126070		

D. Assembly of the Outer Panel

The outer panel should be hoisted into position and the bolts in the lower wing hinges inserted.

The 1/4" bolts through the corrugation valleys should be inserted and drawn up, using the two wrenches A-108602.

The 7/16 and 5/16 bolts in the top, front and rear beam chords joining the outer wing to the center wing should be inserted in position and tightened as follows:

1. 7/16 bolts-Insert the bolt in A-126070 using the wrench to place the bolt in position in the wing, holding the bolt head with socket A-108607 in handle A-108603 so that the nut may be tightened with socket A-108607 in handle A-108604.
2. 5/16 bolts-Insert the bolt in A-126069 using the wrench to place the bolt in position in the wing, holding the bolt head with socket A-108606 in handle A-108603 and tighten the nut with socket A-108606 in handle A-108604.
3. The next step is to insert and tighten the 1/4" bolts through the front and rear beams using A-126068 to insert the bolt and holding the bolt head with socket A-108605 in handle A-108603 and turning the nut with wrench A-108602.

The electrical wires from the outer panel should be pushed through the center section conduit to the junction box in the nacelle and the union conduit splice tightened at the wing gap.

The airspeed lines and the flotation compartment vent lines should be connected at the wing gap.

The gap covers should **now** be installed, and these are attached with No. 10-32 screws. Anchor elastic stop nuts have been installed in the wing to secure these screws.

The final steps are the connection of the electrical conductors for the landing and navigation lights in the junction box inside the engine nacelle and the connection of the aileron, and aileron tab control cables at the inspection door aft of the rear beam on the center line of the nacelle. The outer panel flap control rod is connected at the wing splice.

No adjustment or alignment for incidence or dihedral is necessary. The tabs in the trailing edge of the ailerons, controllable from the pilot's cockpit, provide a means for correcting wing heaviness.

The balanced type ailerons are attached by means of welded steel brackets on the wing, and sealed ball bearing hinges. These brackets should be checked for alignment at the hinge attachment with a straight edge, and if any one of them is out of line the bolts which attach the bracket to the wing should be removed and shims removed or added to make it line up. Retainers have been used on these bolts inside the wing, so that it is not necessary to open the wing to get to them. The aileron frames are of aluminum alloy construction, as shown in Fig. 8, and are covered with fabric. The aileron horn is entirely in the wing, and is attached to a quadrant on the rear beam by passing the end of the horn through the sealed ball joint on the quadrant arm. The aileron is controlled by means of a cable system as shown in Fig. 65.

As the aileron is placed in position on the outer wing panel the tab cables in the panel must be inserted in the end box rib of the aileron, and pulled through to the inspection doors in the upper and lower surface. After the aileron is attached the cables may be installed in the pulleys and connected to the horn on the tab. The dynamic balance coefficient has been reduced to zero by the application of lead weight to the leading edge of the aileron, and by a lead counterweight installed near the center hinge.

E. Maintenance of Wings

The maintenance of the wings proper consists of keeping the finish and the thin metal skin covering in good condition. The wings should be walked on only where covered with rubber matting, or where they are painted black. The walkways adjacent to the fuselage are covered with a thin rubber matting conforming to U.S. Federal Spec. ZZ-M-71. The matting and a gum rubber base pad are cemented together with Plastikon* before fitting the matting to the wing. When installing the walkway strips the edges of the matting and a corresponding portion of the metal wing should be given one thin coat of Neoprene* cement which is allowed to dry for 20 minutes. Apply second coat to each surface and allow to dry to a tacky consistency. Apply the matting carefully making sure to place the edges in the proper location since the surfaces will adhere strongly together and moving will be difficult. Both the above compounds may be thinned with Benzol.*

Note: Only small quantities of Neoprene cement should be kept on hand since it will jell to a unusable state in approximately 3 months.

Inspect all bolts, fittings, and joints occasionally for wear. The long bolt used to attach the aileron control horn to the aileron should be checked frequently for tightness. If this joint becomes loose, aileron flutter may develop. The counterweight bracket attachment should also be checked for tightness. The aileron and wing flap hinges have sealed ball bearings and should require no further lubrication until major overhaul. The interior of the wing may be inspected through the wheel well and through the hand holes and inspection plates provided on the lower surface. Do not lean ladders against the leading or trailing edges. Use stiff pads or borads when access to unprotected parts of the wing is necessary. Repairs should be made in accordance with the instructions contained in Appendix I.

For additional inspection of wings, ailerons, and flaps refer to Section XXIII.

*See list of Compounds in Appendix IV.

F. Split Wing Flaps

Split trailing edge flaps extend from the aileron to the side of the fuselage on each side of the airplane. They have a cross section of approximately the shape of an airfoil and are structurally similar to the ailerons. The outer and center panel flaps are separate and are controlled by push-pull rods actuated by hydraulic cylinders located on the rear face of the rear beam. The flap operating mechanism is shown diagramatically in Fig. 13. The flap construction is shown in Figs. 9 and 10.

The split wing flaps are assembled to the wing structure by means of a single bolt at each flap hinge. The hinge plugs on the flaps are inserted into the forged sockets rigidly attached to the trailing edge ribs, and the bolt gently tapped into place at each attachment point. The center hinge of the outboard flap is supported by a bracket from the rear beam in the same manner that the aileron hinges are supported.

The flap horns are entirely inside the wing trailing edge section and are attached to the flap operating mechanism by a sealed ball joint. Access to these joints is provided by means of inspection dorrs in the upper and lower surfaces of the wing trailing edge section. Spring clips and lockpins are provided to prevent flaps from drooping due to normal oil leaks **past the** piston at low oil pressure when the airplane is at rest. In case of replacement of flap, it is essential that the spring and pin line up for engagement.

The hydraulic flap operating hand pump in the pilot's cockpit contains an integral oil reservoir. An adjustable relief valve has been built into the pump. This valve is shown diagramatically in Fig. 13. An acorn-shaped dust cap, shown in Fig. 5, covers the adjusting screw. This valve is set to by-pass oil from the flap cylinders to the reservoir when the load on the flaps is such that the working pressure of 815 pounds per square inch for which the system is designed is exceeded. No further adjustment should be necessary. Oil may be added to the flap system by removing the circular air chamber from the reservoir opening. Fill the reservoir until it overflows with "Sperry Servo Oil" or "Mobiloil SS Oil". Replace the air chamber.

NOTE: The air chamber is designed to prevent excessive pressure from being built-up in the pump when the system is filled with the flaps in the "UP"position. This is necessary due to the fact that there are piston rods on only one side of the operating cylinder pistons. When the flaps are up, these piston rods are extended and the cylinders are completely filled with oil. Consequently, if the pump reservoir is also completely filled, provision must be made in the system for the oil that is displaced by the piston rods when the flaps are lowered. THE AIR CHAMBER MUST ALWAYS BE IN PLACE WHEN THE FLAPS ARE OPERATED.

G. Maintenance of Flap Mechanism

Air in the flap hydraulic system can be detected by the "soft" feel of the pump handle. To bleed air out of the system, the procedure is as follows:

1. Lower the flaps.
2. Remove the small screws from the inboard special bleeder fittings, two of which are provided on the top of each cylinder. (G.L.M. Dwg. B-126440, Cleveland Pneumatic Dwg. A-4866.)
3. Slip rubber drain hose over the special bleeder plugs and back off the valve screw a few turns. (See G.L.M. Dwg. B-127581.)

4. Operate the hand pump slowly, adding oil through the filler opening carefully.

NOTE: It is very important that the new oil be strained through a very fine screen or cloth to prevent dirt and grit from entering the system and scoring the finely ground valves and seats.

5. When the discharged stream of oil shows no sign of air bubbles, close the bleeder plug needle valve by tightening the valve screw. Remove the drain lines and repeat operation on the outboard bleeder fittings after turning the selector valve handle on the pump to "Flaps Up" position.

6. Replace and safety the screws in the top of the bleeder fittings, fill the reservoir, and pump the flaps up.

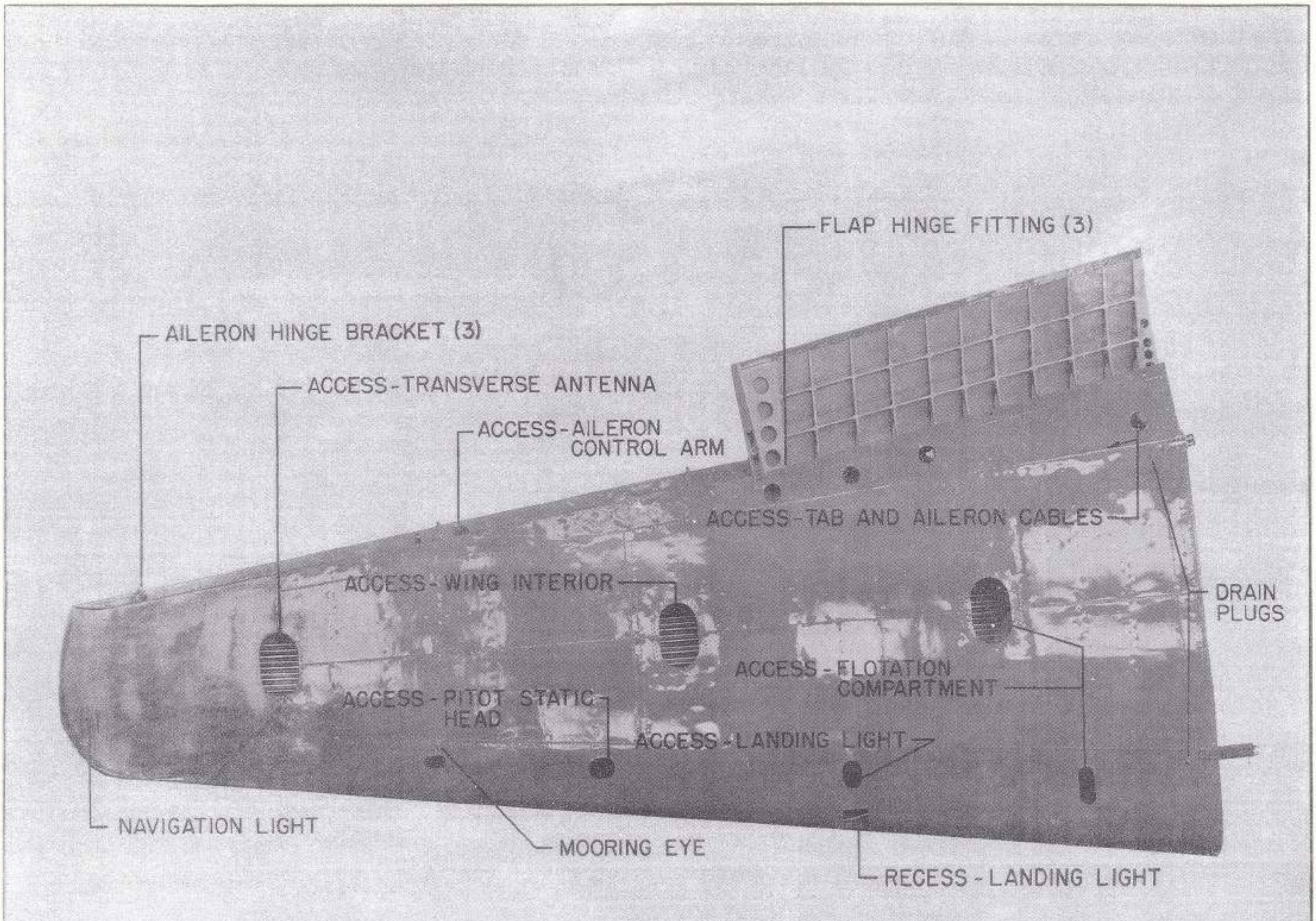


FIGURE 6 LEFT OUTER WING PANEL - BOTTOM SIDE

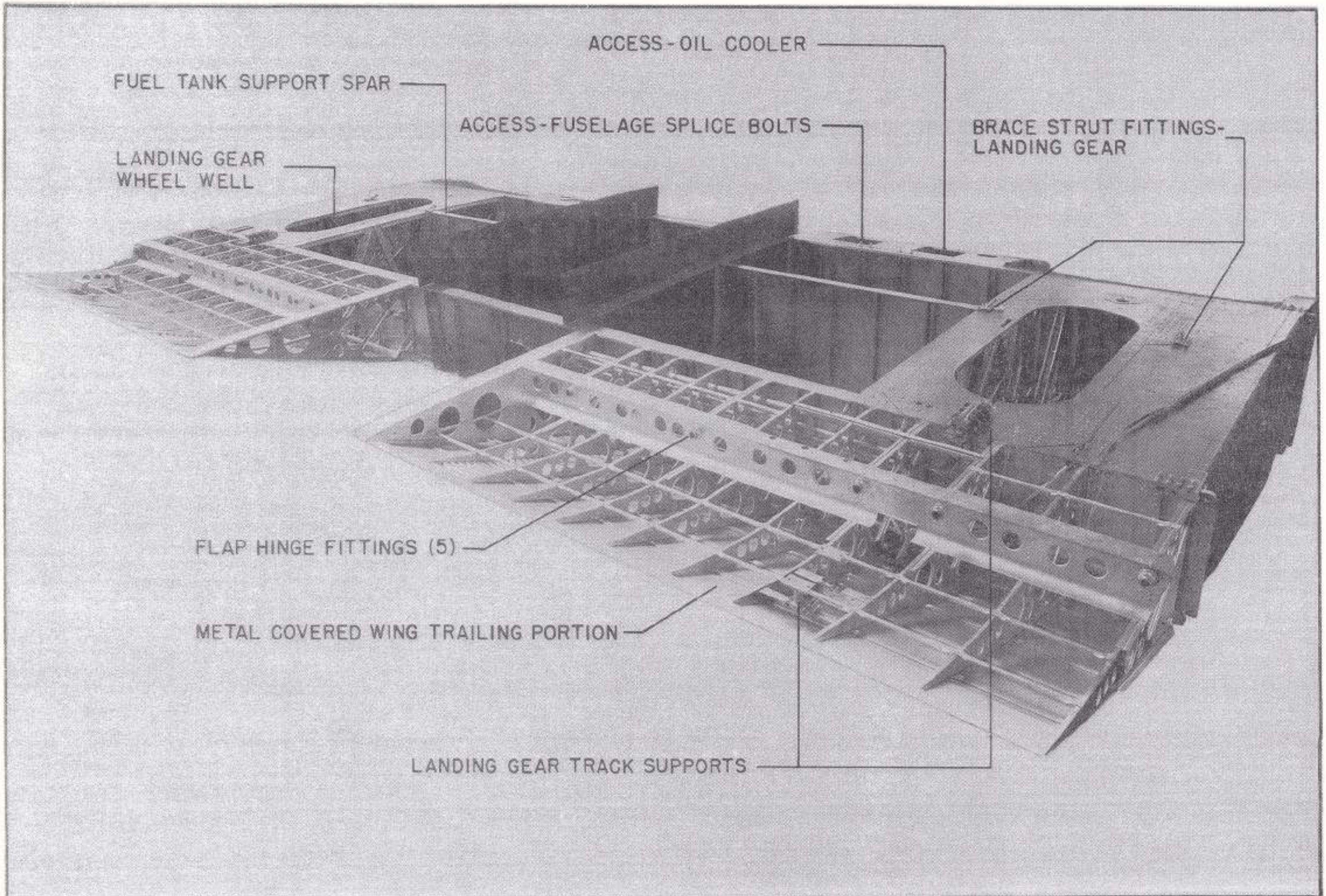
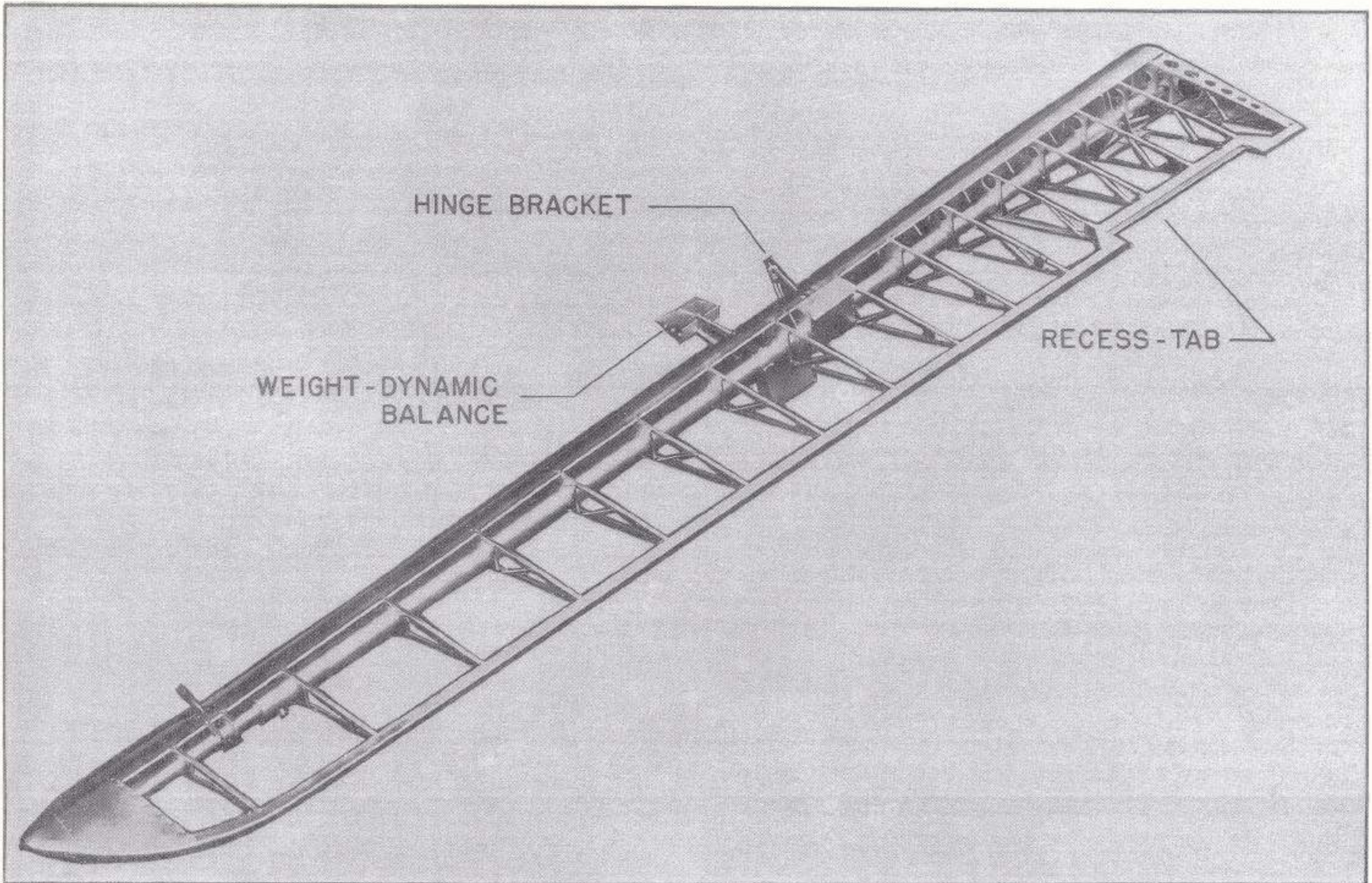


FIGURE 7 CENTER WING FRAME



A

FIGURE 4 AILERON FRAME ASSEMBLE

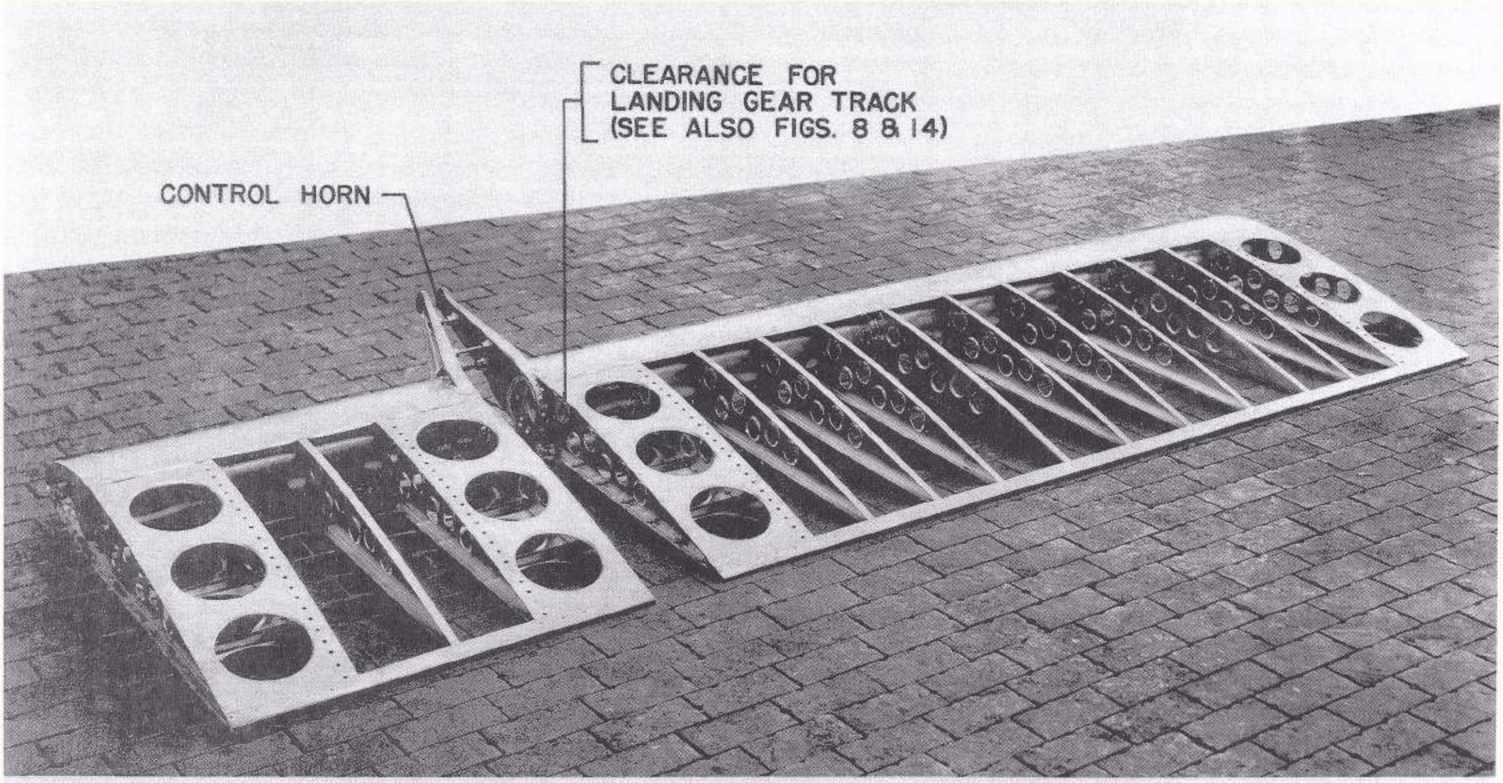


FIGURE 9 FLAP FRAME-CENTER WING

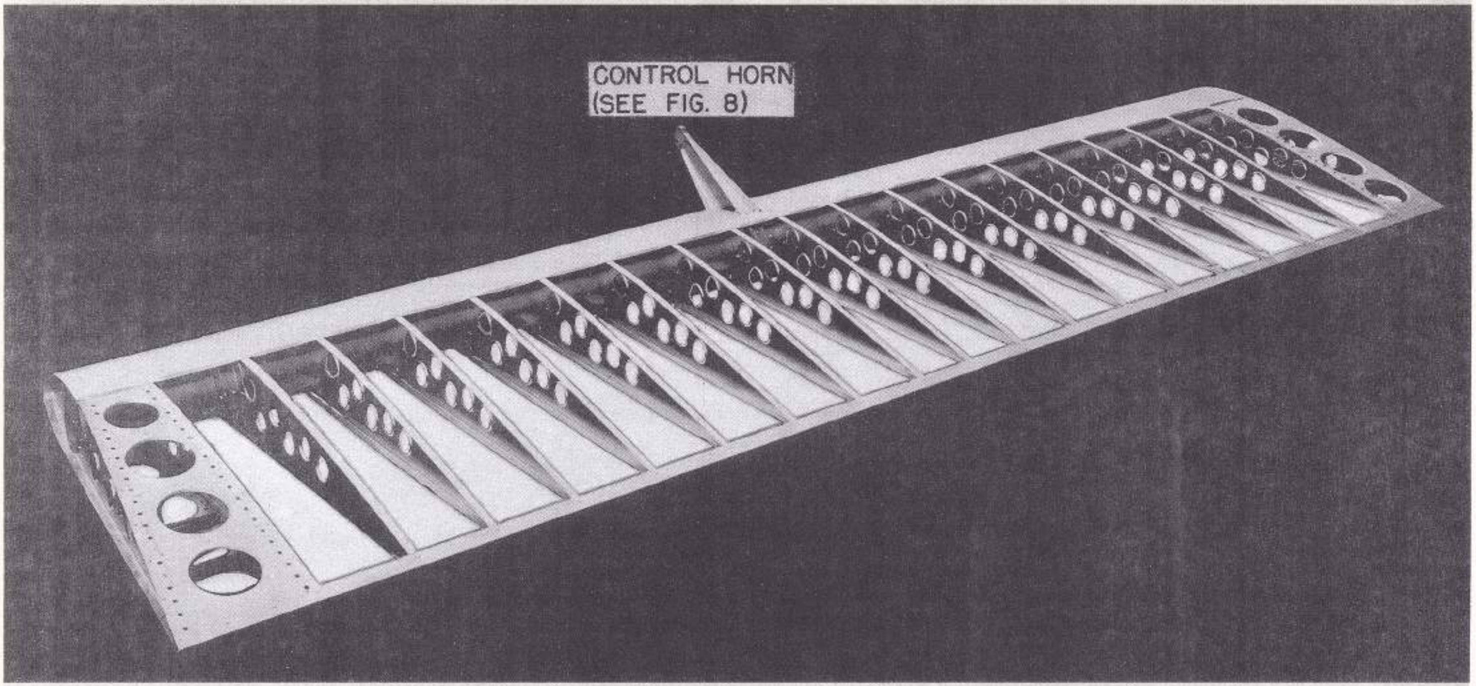


FIGURE 10 FLAP FRAME - OUTER WING

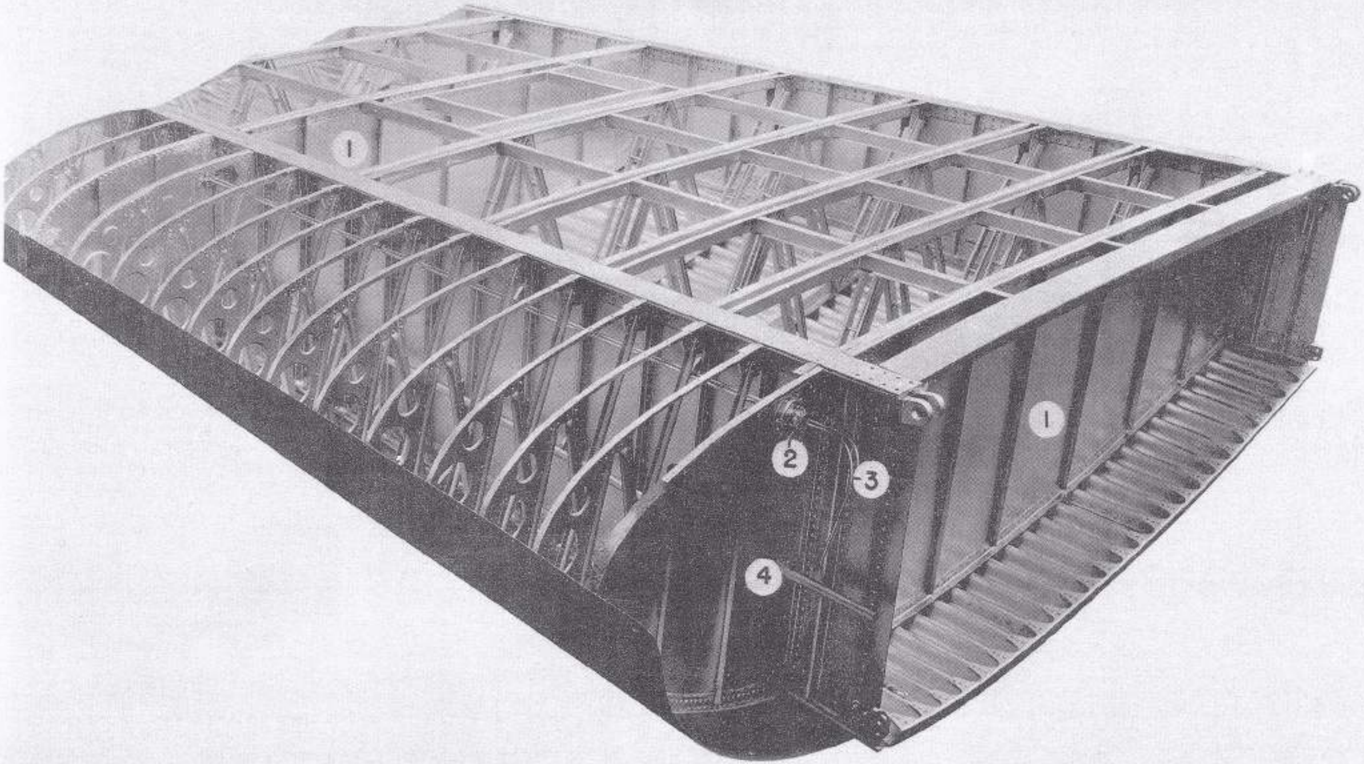


FIGURE 11 FLOTATION COMPARTMENT IN OUTER WING

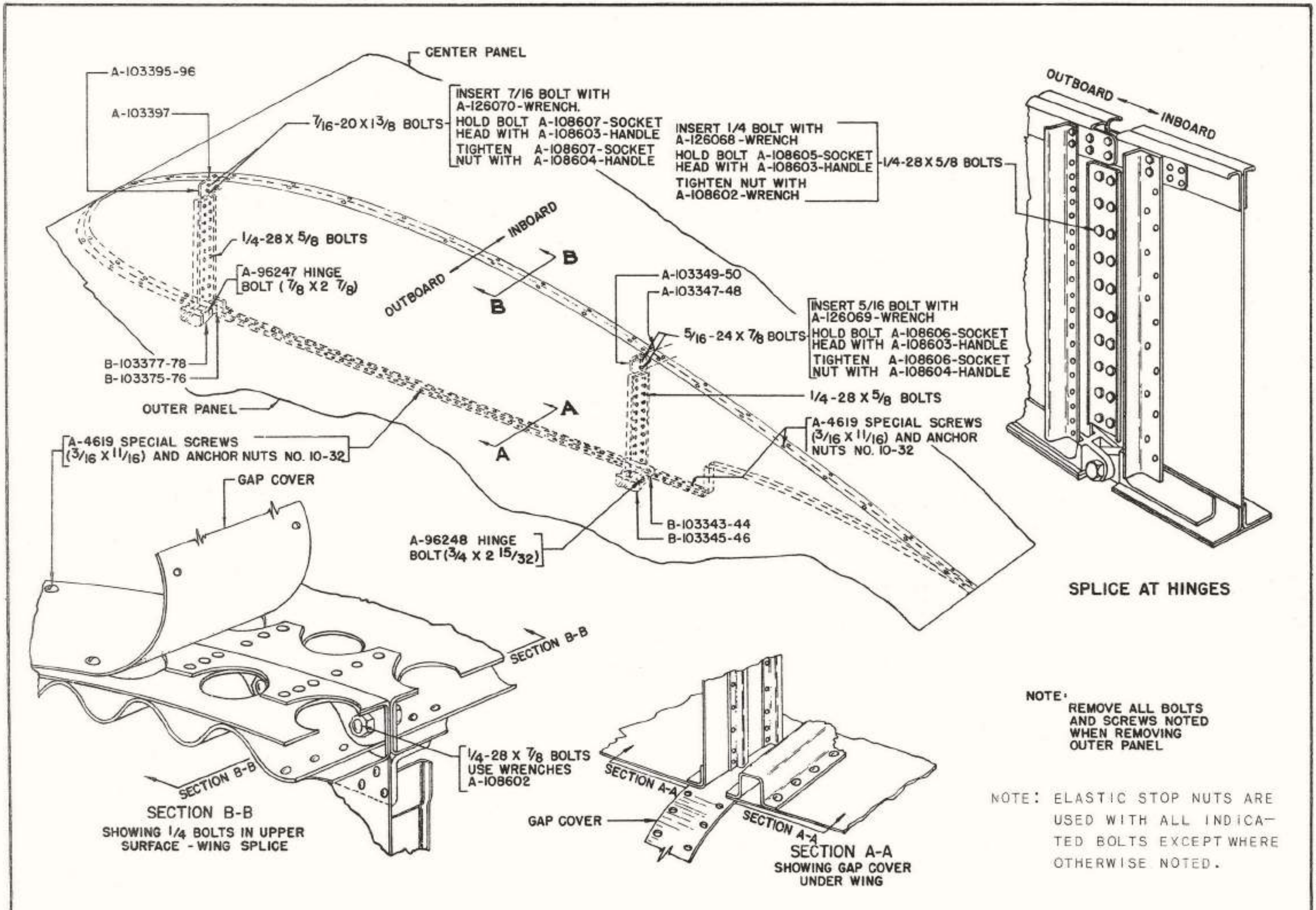


FIGURE 12 MODEL 139-W WING SPLICE DIAGRAM

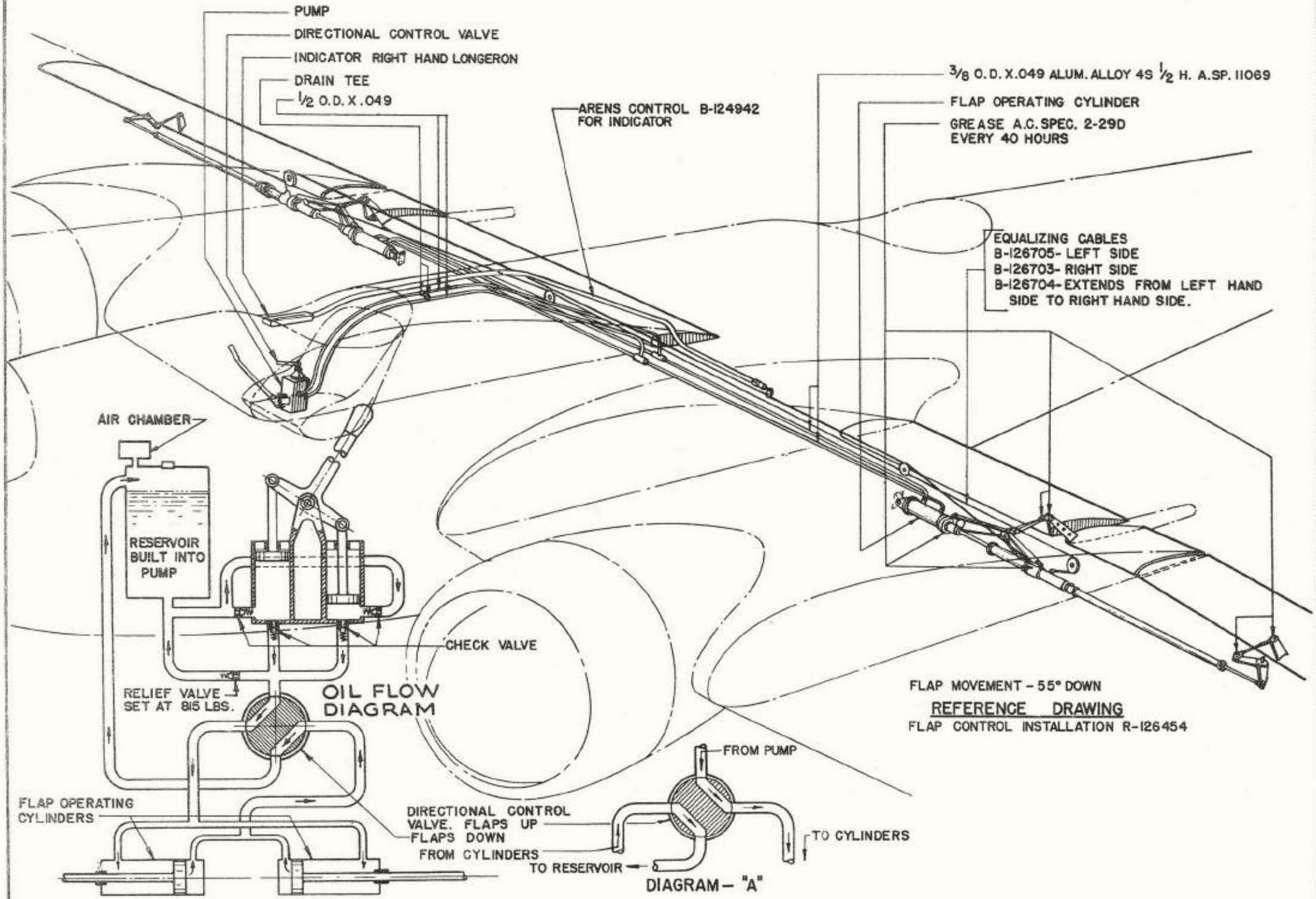


FIGURE 13 MODEL 139-W FLAP CONTROL DIAGRAM

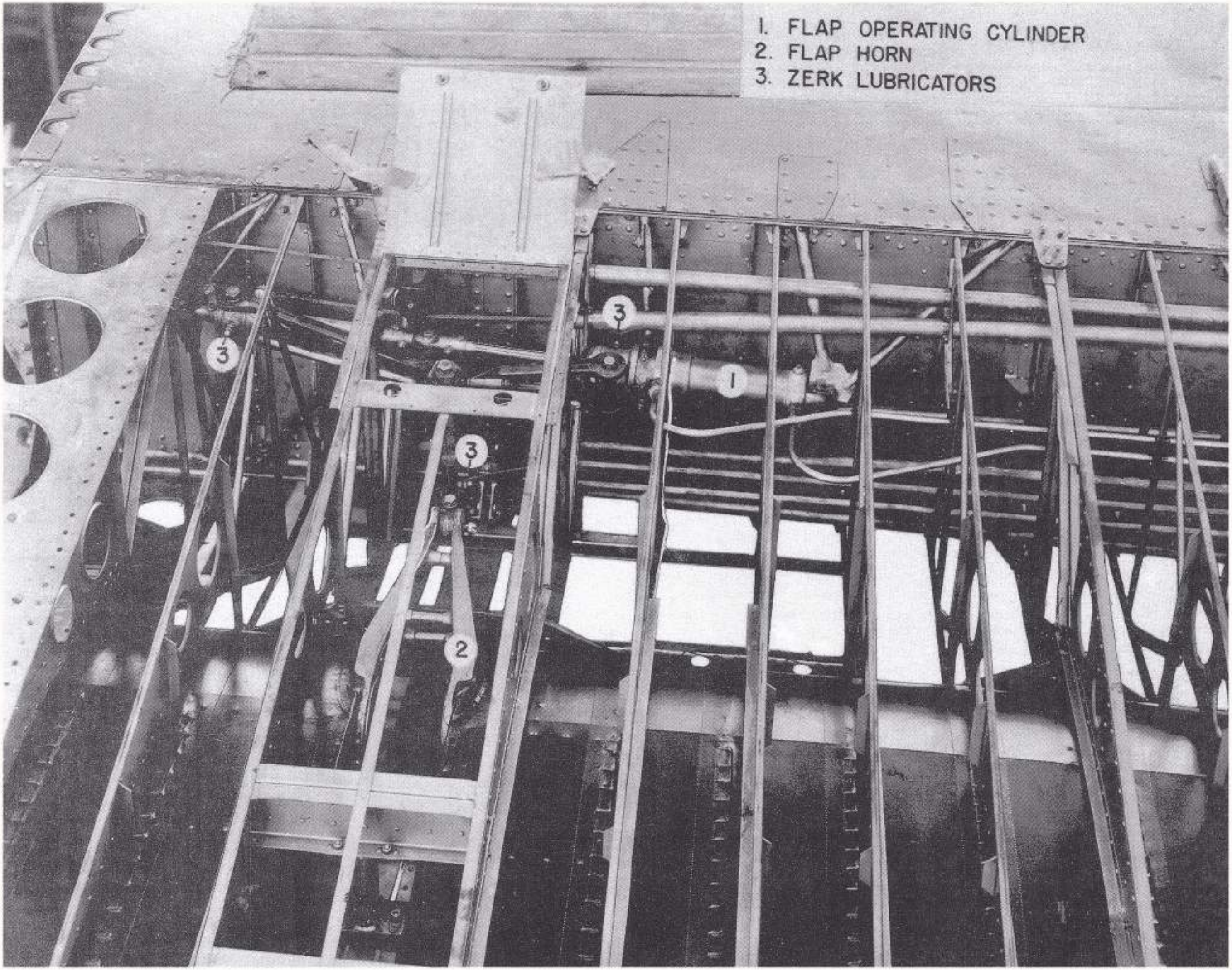


FIGURE 14 FLAP OPERATING MECHANISM IN CENTER WING

SECTION V

EMPENNAGE

A. Description

The empennage group shown in Fig. 20 includes the elevator panels, balance tabs, and trimming tabs; the horizontal stabilizer panels; the vertical stabilizer; the rudder, and the rudder trimming tab.

The vertical and horizontal stabilizers are of the fixed, cantilever type, constructed entirely of aluminum alloy, except for the attaching fittings which are of steel. Figures 16 and 17 show these surfaces. The fixed stabilizers are attached to the fuselage by means of tapered, heat treated steel bushings inserted through the terminals and secured by a bolt and nut at each terminal. A special cup washer is used under each nut. The movable surfaces are supported by hinges which are assembled with outriggers, (Fig. 26) installed on the rear spars of the fixed surfaces.

The rudder and elevators are of aluminum alloy construction internally and are fabric covered. Essentially the internal structure of each movable surface consists of a torque tube to which are riveted the former ribs as shown in Fig. 19. Aerodynamic balance of these surfaces is accomplished by incorporating lead weights inside the nose sections which extend beyond the hinge centerline of each surface. A trimming tab operable from the pilot's cockpit, and a balance tab is inset in the trailing edge of each of the movable tail surfaces. Brackets and pulleys which are used to support the tab operating cables are secured to the torque tubes within the fabric covering.

The movable surfaces are operated by means of cables which are secured to the control quadrants riveted to the torque tubes. The cable system is shown diagrammatically in Fig. 65. A complete description of the control system is given in Section XVIII Surface Controls.

The empennage fairing which serves to streamline the tail of the fuselage and to smooth out the air flow from the empennage surfaces, is constructed in six separate sections. Installation of these sections is described in paragraph F.

B. Flotation Compartments

One flotation compartment has been provided in each horizontal stabilizer between the spars, and drain plugs and vents have been provided the same as for the wings. These compartments are vented near the top of the vertical stabilizer, the vent lines passing from the horizontal stabilizer through the fairing to the aft face of the rear spar of the vertical stabilizer. These lines are accessible by swinging the rudder off the center line of the fuselage. In order to connect or disconnect the unions in these lines, it is necessary to remove the empennage fairing aft of the fuselage tail post.

C. Assembly of Vertical and Horizontal Stabilizers

The stabilizers should be positioned on the fuselage with the holes in the fittings lined up. The electrical wires from the vertical stabilizer should be pulled through the grommet in the fuselage as the surface is brought into position. The surfaces should be bolted in place with 5/16-24 bolts, taper bushings, and hinge caps provided. Refer to Fig. 15.

A disconnect plug has been provided in the fuselage near the front vertical stabilizer spar to facilitate connecting the electrical wires from this surface.

The two elevator vane pulley brackets should next be installed.

D. Assembly of Rudder

The lower rudder hinge bracket D-124350 should be bolted to the fuselage and with the airplane level laterally and longitudinally the alignment of the hinges should be checked with a plumb bob. NOTE: The hinge fittings on the movable surfaces located from the bolt holes in the outriggers on the fixed surfaces, and these bolt holes should line up. The rudder control quadrant D-124374 should be next bolted to the rudder spar with the hinge socket A-106257. The rudder may then be slipped in place and bolted up. The rudder control cables may now be attached to the quadrant arm, and the rudder vane cables connected up and adjusted, as described in Section XVIII on surface controls.

E. Assembly of Elevators

The elevators should be spliced together by bolting in place the control quadrant D-163544, after which the entire assembly should be bolted to the outriggers on the fixed surface. In case of replacement of any of the hinge brackets their alignment should be checked. The elevator and elevator vane control cables should be connected up and adjusted as described in Section XVIII on Surface Controls.

F. Assembly of Fairing

The empennage fairing is installed in six sections beginning with the forward section and working aft. Anchor elastic stop nuts permanently attached to the supporting structure are provided and the machine screws should be inserted and left loose until all sections are in place. As the screw holes are oversize the sections may be shifted to fit tight all around, then the screws tightened. The forward portion (vertical stabilizer to fuselage) is soft aluminum and must be bumped to suit the variable corrugations on the fuselage at each assembly. The fairing is shown in Fig. 21.

G. Abrasion Shoes (**Optional Special Equipment**)

An abrasion shoe is installed over the nose section of the horizontal stabilizers. These shoes are cemented to the unpainted surface of the stabilizer after a cleaning bath of denatured alcohol which must be wiped off before it dries. A final cleaning using benzol is given the metal surface after which handling should be avoided.

1. Cementing

Prepare first coat for metal by mixing one part Goodrich Vulcalock cement with two parts benzol--approximately. In applying this first coat, brush well. After this has dried, apply one or two coats of straight Vulcalock, letting each successive coat dry. Enough Vulcalock should be applied to give a golden brown color. Let dry absolutely hard, preferably over night, before applying the rubber cement.

Thoroughly wash surfaces of rubber to be cemented (fabric reinforced side of flat stock and inside of V-shaped piece) with benzol. Apply coat of Goodrich #1 Rubber Cement, thinned with approximately one part benzol to two parts #1. This coat should be applied uniformly and liberally enough to penetrate rubber as indicated by swelling of rubber before drying. Apply medium light coat of #1 cement, thinned as above, over Vulcalock on airplane. Let cement on both rubber and airplane dry to a point of strong tackiness. If tackiness of rubber is lost in waiting for cement to dry on the airplane, freshen rubber with another light coat of cement.

2. Application

Roll flat stock in clean piece of fabric liner, or it can be held by a helper during application. Apply to airplane by sticking the forward edge only along the entire length and then working the remainder down by stroking with the palm of the hand in such a way as not to trap air between the rubber and the cemented surface of the airplane. If by accident stock sticks down in error, pull it loose with a sharp jerk. Roll down firmly under pressure with a rubber roller or the equivalent. Wipe off the forward edge of rubber to be overlapped by V-shaped piece and cement with #1 cement indicated above.

Roll V-shaped piece of fabric, rolling outward so as to open or spread the "V." By keeping the stock folded back on itself and the "V" opened wide, the center scratch line on the inside of the rubber can be laid along the marked center line of the entering edge. In applying, stick the center only. In going around the curvature the stock should be given a longitudinal stretch so that later the flaps can be stuck down without wrinkling. Work flap edges of stock down by stroking so as to avoid trapping air. Roll down under pressure.

3. Oil-Proofing

After stock has been rolled down thoroughly and all trapped air let out by puncturing rubber with a pin, and all surplus trimmed, the edges should be "oil-proofed" to prevent gasoline, oil, or other solvents from attacking the cements and weakening the bond to the metal. This is done by masking off around all edges so as to leave a strip of about 1/8" on rubber and 1/8" on metal exposed all the way around edges.

To these strips apply: first coat straight Vulcalock--let dry hard; second coat made up of nine parts Vulcalock and one part lacquer thinner--let dry until not quite hard; third coat of straight lacquer.

Remove masking tape.

H. Maintenance

Make a daily inspection to see that the finish and covering of the surfaces are in good condition.

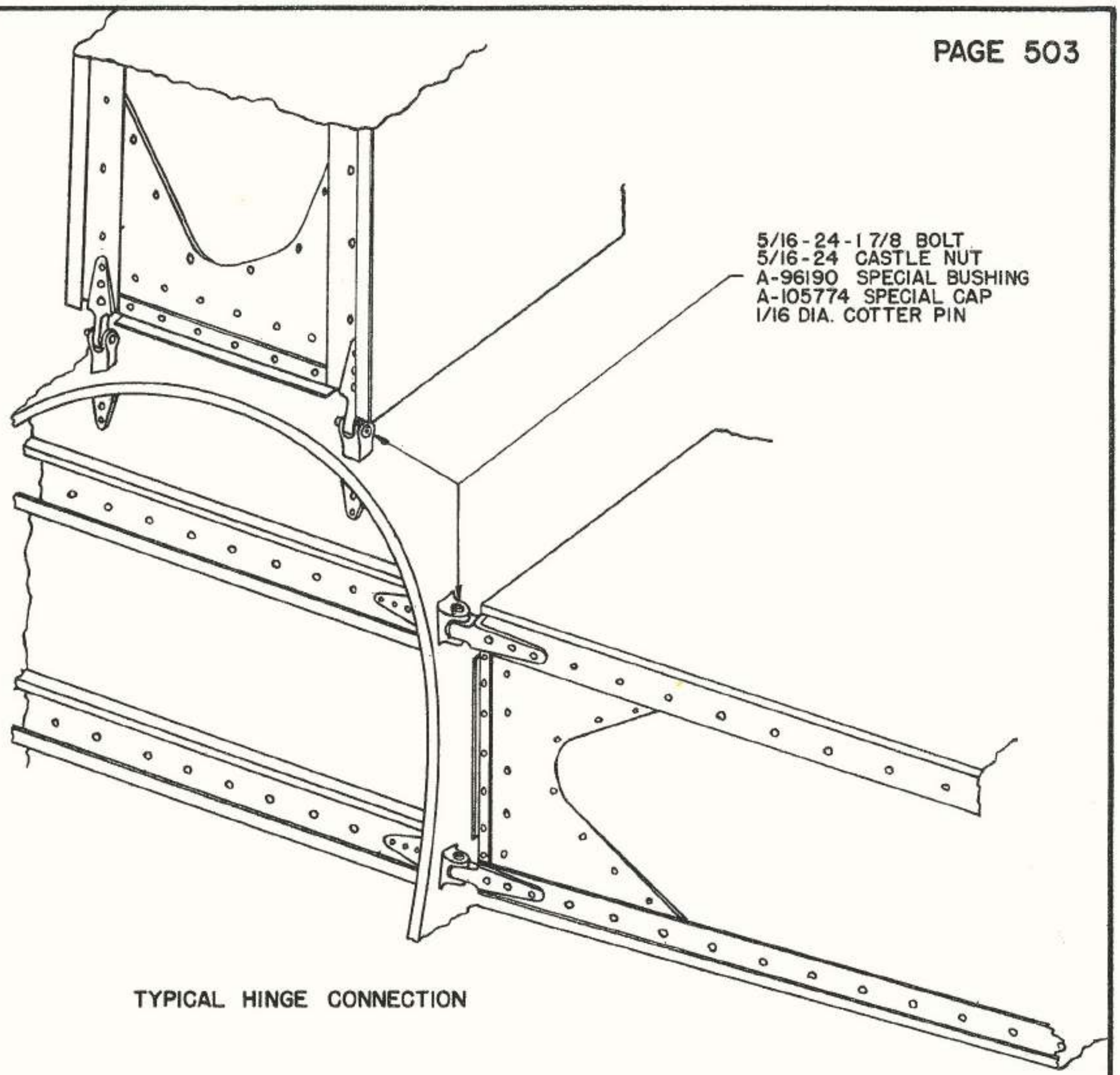
Carefully inspect all elevator and rudder horns and hinges every twenty (20) hours for security of attachment.

If any shake develops in the vertical or horizontal stabilizers, the hinge bolts should be checked for tightness. If it is necessary to tighten these bolts the fairing must be removed to gain access to them.

Inspection holes have been provided in the fairing at the front and rear vertical and horizontal stabilizer connections for checking the cottering of the bolts.

The rudder and elevator hinges are sealed ball bearings and require no lubrication.

Remove drain plugs located in flotation compartment of horizontal stabilizers every forty (40) hours to allow any condensation to drain out.



TYPICAL HINGE CONNECTION

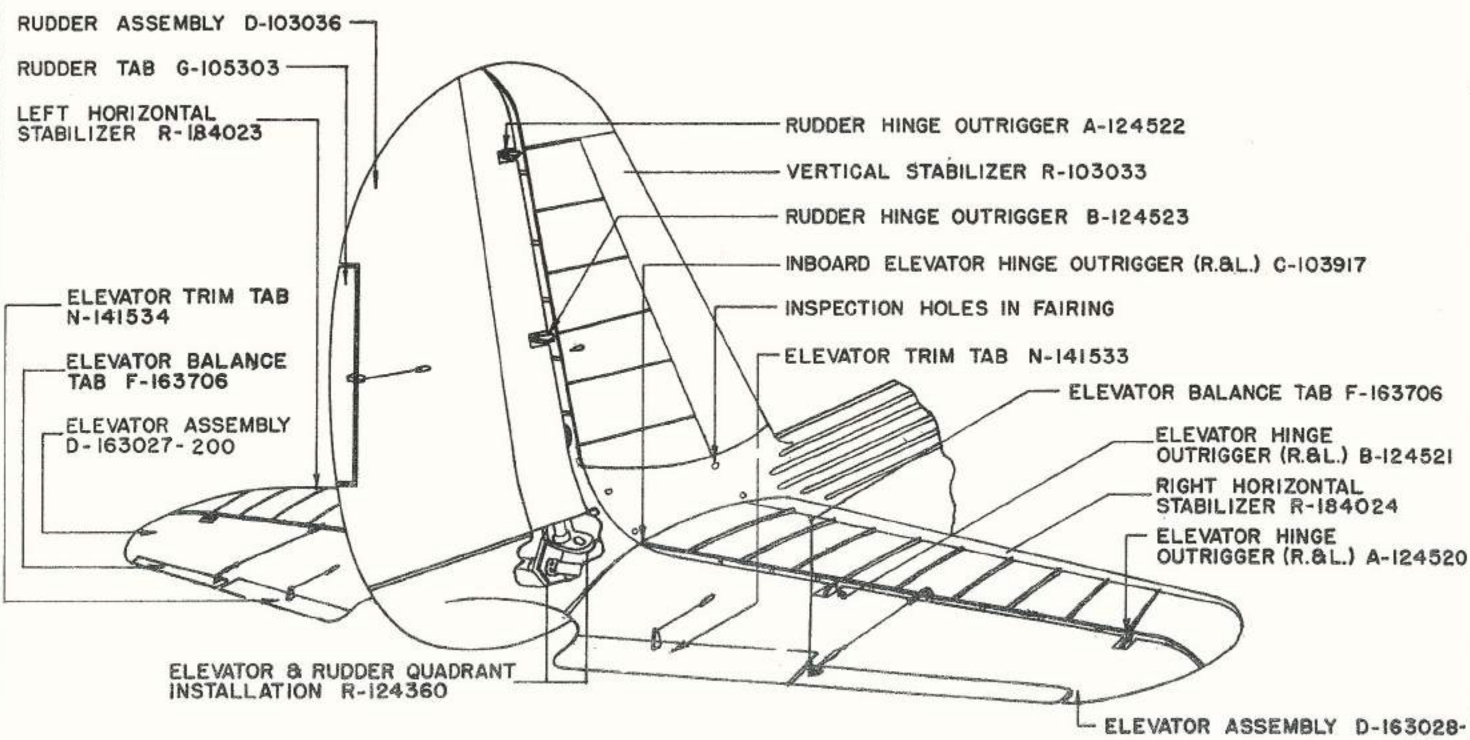


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FIGURE 15 MODEL 139-WH3 EMPENNAGE DIAGRAM

C

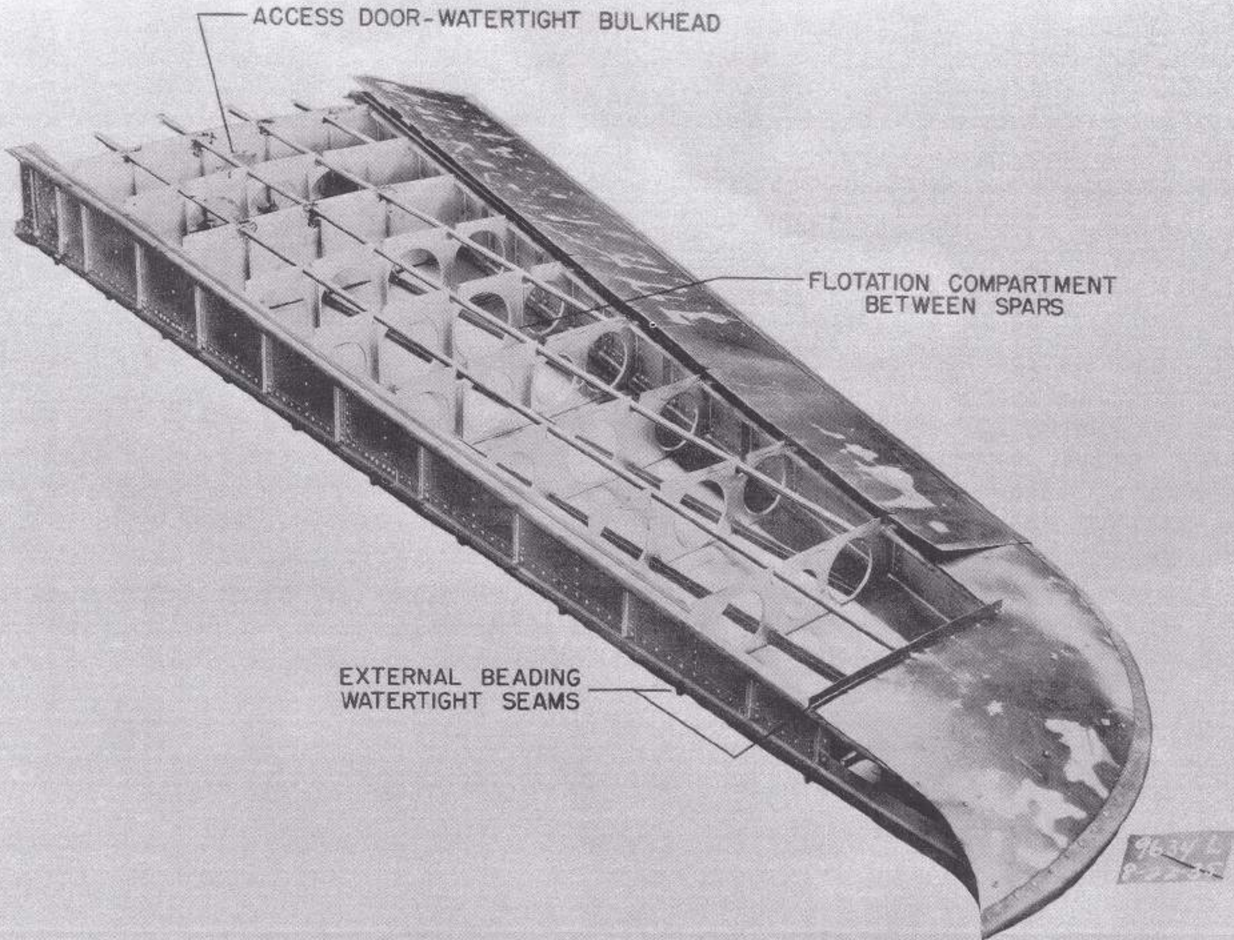

FIGURE 16 HORIZONTAL STABILIZER

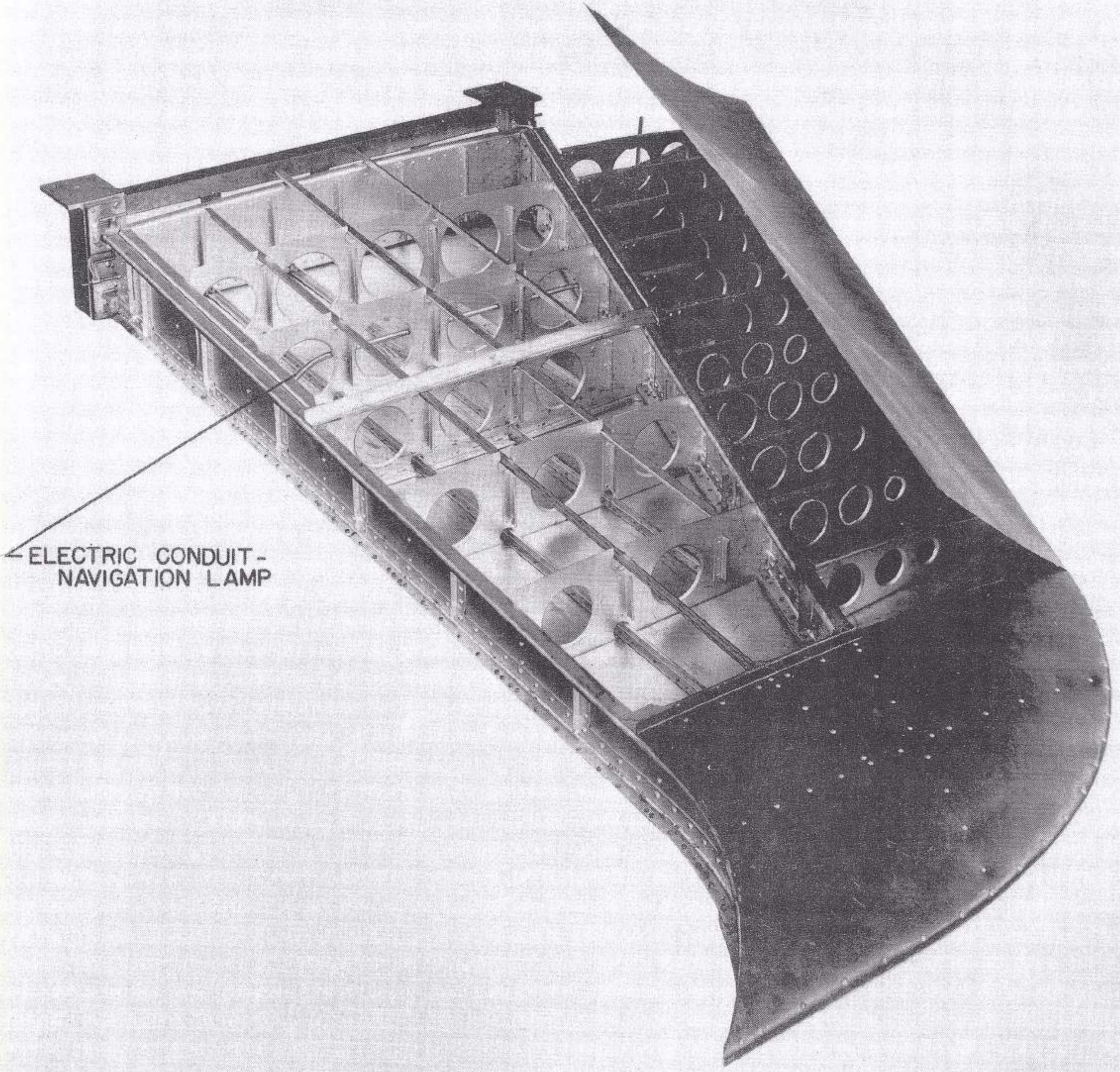

FIGURE 17 VERTICAL STABILIZER

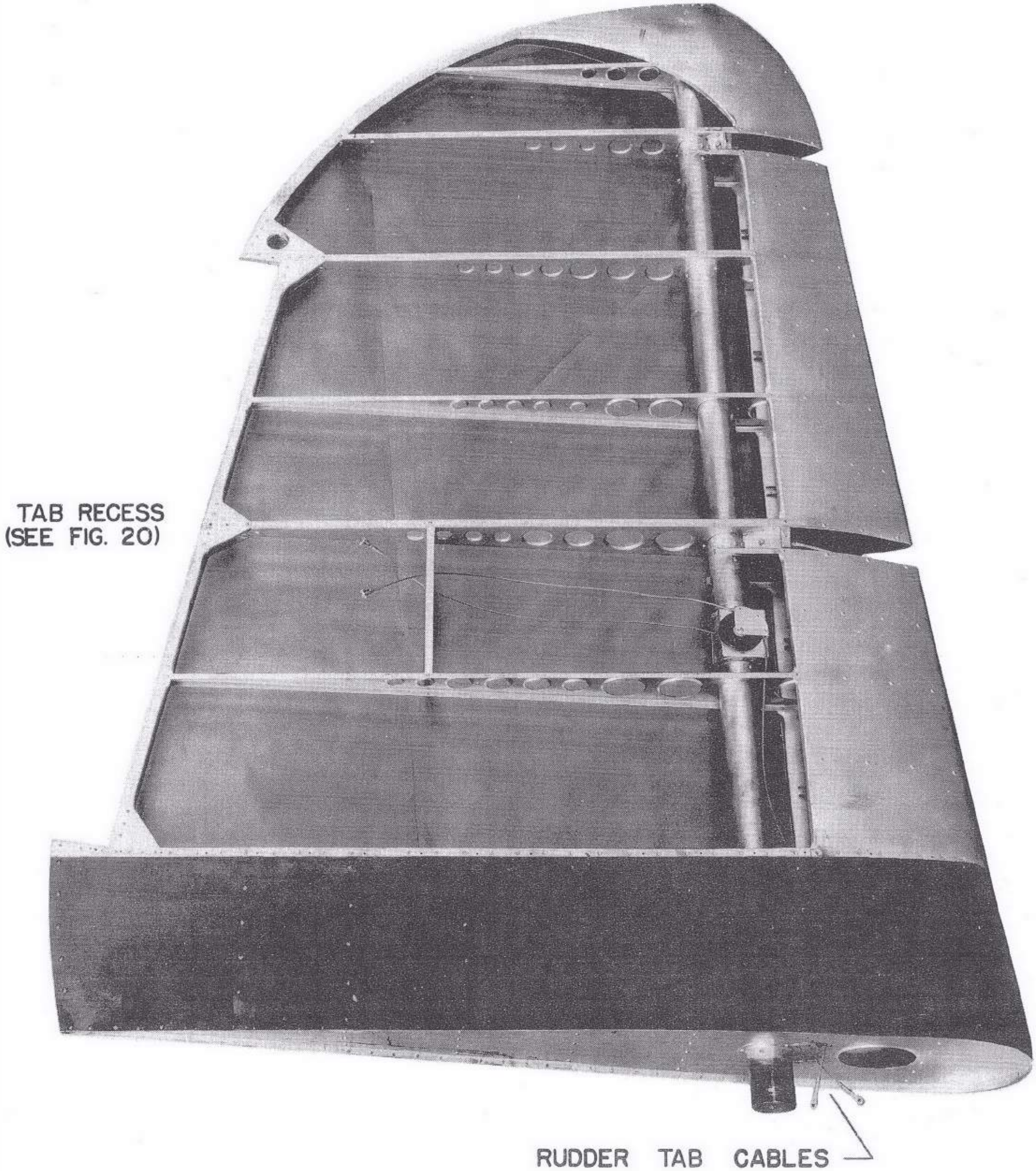

FIGURE 18 RUDDER FRAME ASSEMBLY

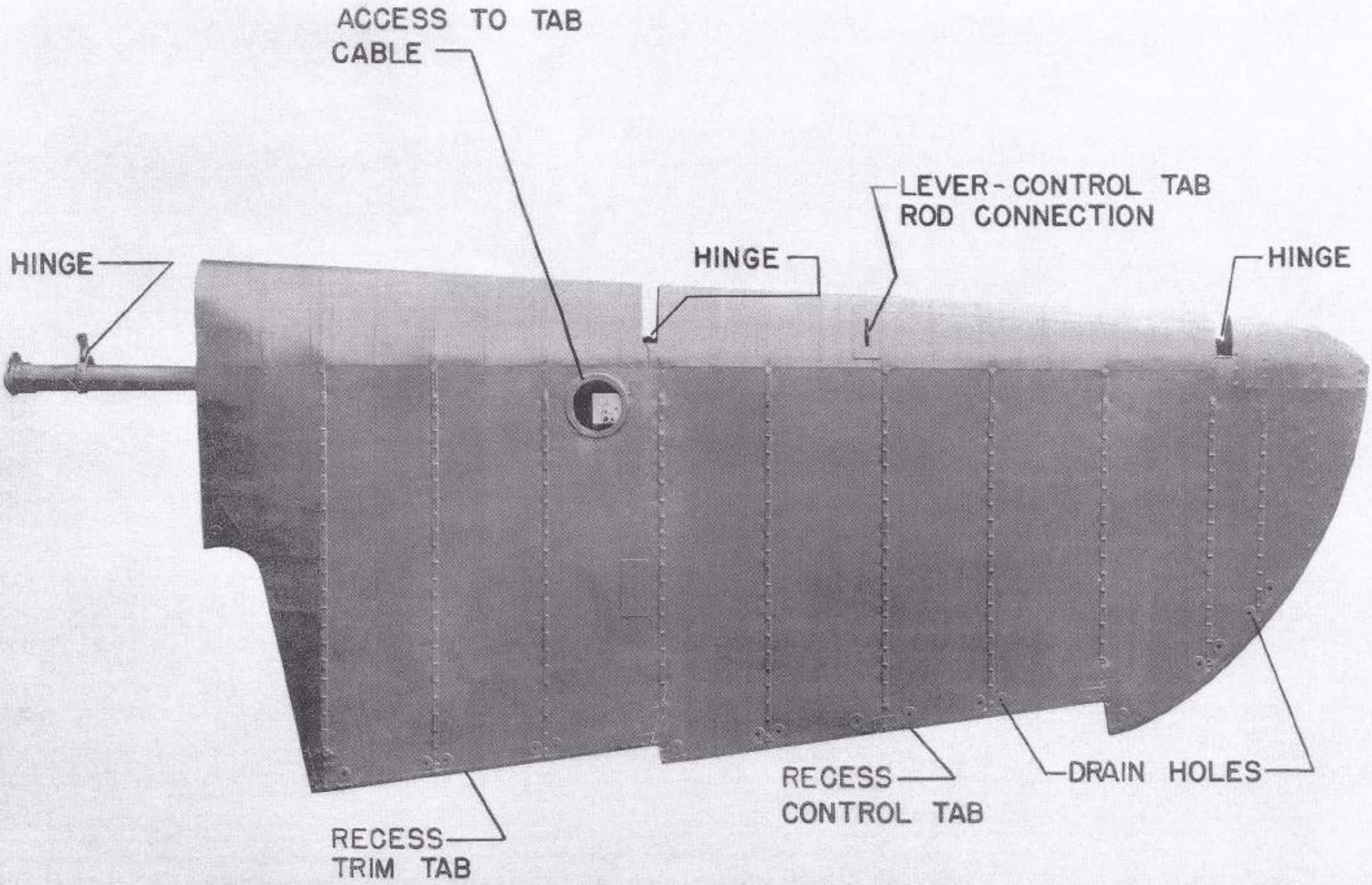

FIGURE 19 ELEVATOR PANEL - LEFT SIDE BOTTOM

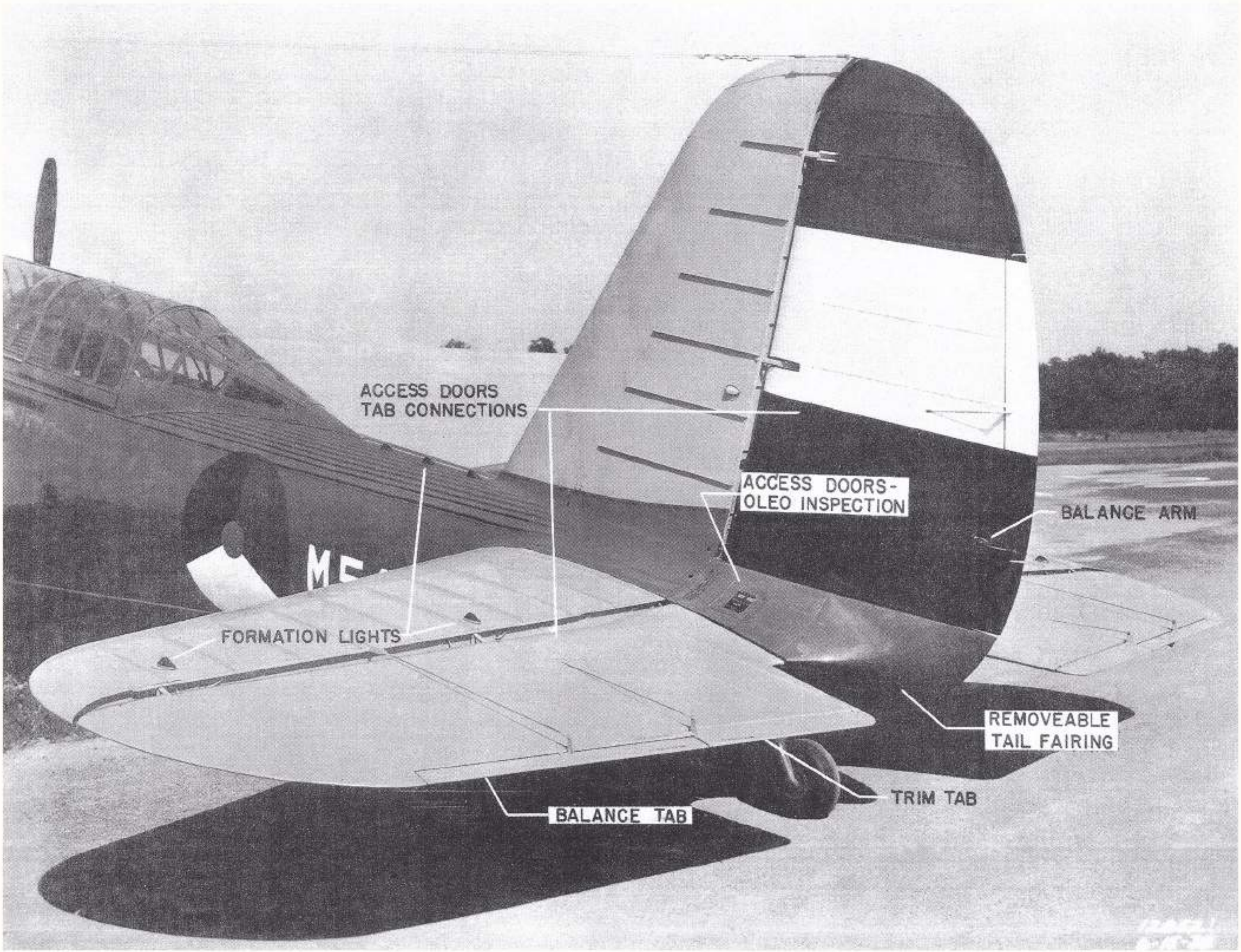

FIGURE 20 EMPENNAGE ASSEMBLY

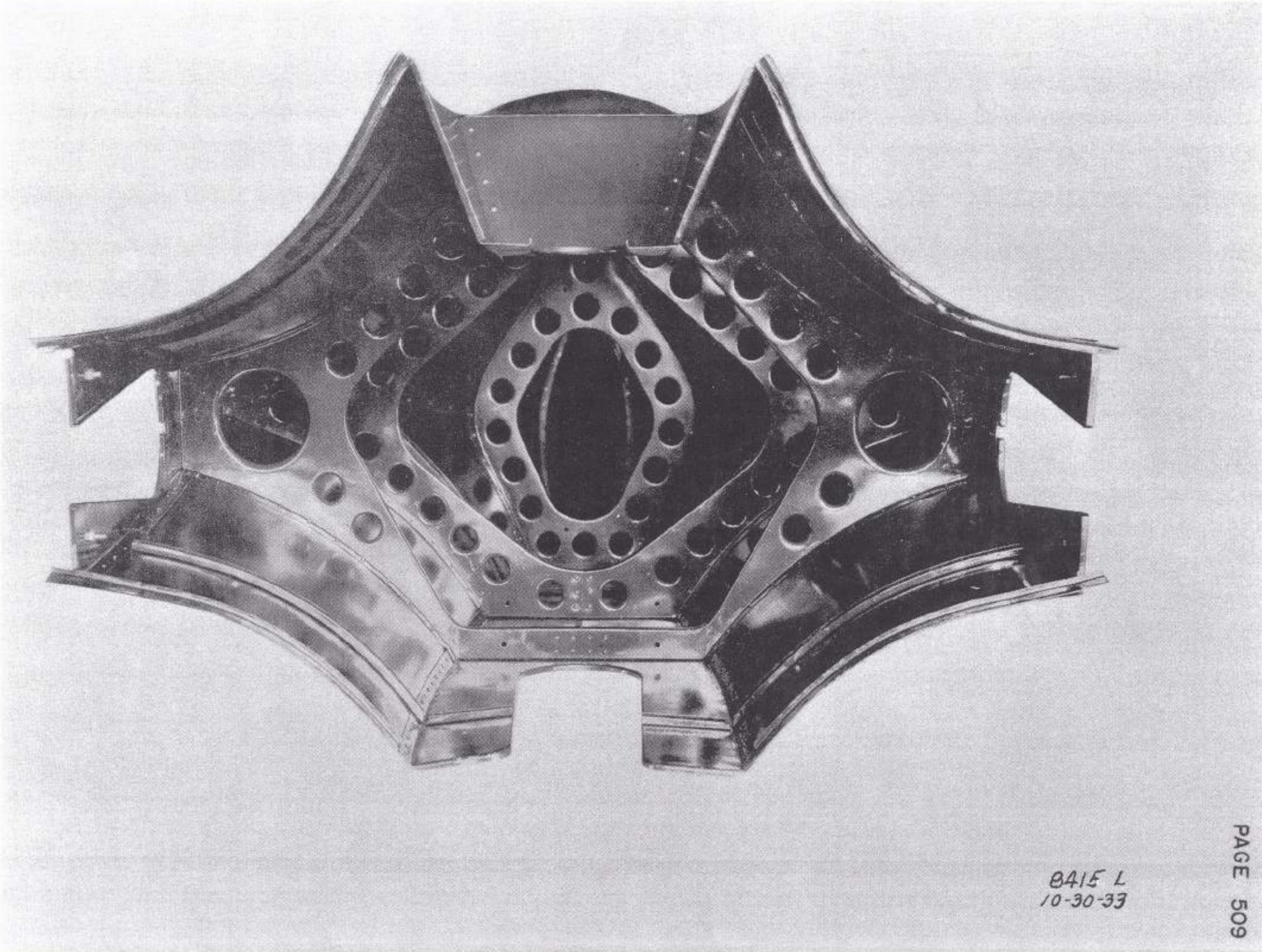

FIGURE 21 REAR SECTION - EMPENNAGE FAIRING

SECTION VI

C. FUSELAGE

A. General Description

The fuselage is of riveted aluminum alloy, semi-monocoque construction, comprising a Nose, Center, and Tail section. These sections are joined together with reinforcements at the abutting surfaces by means of bolts and screws. Each section is constructed in a jig so that any one section is interchangeable from one airplane to another.

In general, the skeleton is constructed with closely spaced tubular rings and fabricated bulkheads which are secured to channel section longerons and similar formed longitudinal stiffener sections. The shape is generally tapered and oval throughout the length. Except for the section forward of, and including the bomb doors, the top and bottom surfaces of the fuselage are covered with corrugated aluminum alloy sheet riveted to the frame. Torsional and sheer stresses are carried by the smooth side skins rigidly riveted to the frame structure. All openings for doors, cockpits, and windows are adequately reinforced as illustrated in Figures 22 to 24B.

The Nose section of the fuselage includes the front gunner's and bomber's compartments and the forward portion of the pilot's cockpit. A revolving turret in which a flexible machine gun may be mounted is installed in the front of this section. This unit is demountable as described in Section XVI.

The Center section of the fuselage is built around, and integral with, the center section of the wing. The rear portion of the pilots' cockpit, the bomb bay, and the wing stubs comprise this section. Space is provided in the wing stubs for the fuel and oil tanks and landing gear. The engine nacelles are installed at the leading edge of the wings on this section.

The Tail section of the fuselage has accommodation for the radio and operator forward, a commander directly behind the radio operator and the relief pilot-gunner aft. Provision is made for mounting a machine gun on top of the fuselage directly behind the co-pilot, and an opening is provided in the floor aft of the co-pilot's cockpit through which another gun may be operated.

B. Assembly

The wing center section should be leveled and supported from the four hinge fittings on the front and rear beams. The rear part of the fuselage should be brought into position with a small gap between the two sections. All the conduits, tubing, and etc., should be checked over to see that all connections can be made after the two sections are assembled together. Some electrical wires have to be inserted in the conduits as the two sections are brought together. If the fuselage sections have previously been assembled, all holes through the fuselage and the splice plates will be drilled. However, parts furnished as spares, such as fuselage sections, splice plates fillers, etc., are not drilled. Therefore, the spare parts should, if possible, always be drilled from the part to be matched. If this is not feasible, the old part should be used as a drill template. Should neither of these methods be possible, the parts should be drilled in accordance with the dimensions given on the drawings. See Figure 22.

The holes for the fore and aft bolts in the fuselage rings should be lined up and these bolts inserted. In case any of these holes are out of alignment it may be because the rings have distorted slightly in shipping, and they should be carefully forced into position rather than the holes elongated, since the fuselage sections are jig drilled. The rear portion of the fuselage should be supported at the tail post, and by means of a cradle at the ring bulkhead immediately forward of the gunner's cockpit. The corrugations should be protected by a felt pad. The external splice plates for the sides and top and bottom should be installed. The bolting of the upper and lower longeron splices completes the assembly of this joint. The nose section should be assembled in a similar manner, the type of joint being the same as in the rear. The forward part of the fuselage may be supported by means of a cradle at the ring bulkhead just aft of the lower exit door and on the ring bulkhead near the forward gunner's cockpit, using a felt pad for protection.

The bomb bay doors should next be assembled to the structure. The end hinges should be slipped in place on the hinge tube before the doors are brought into position. The center hinges are in pairs and should be bolted together. Refer to Section XV for a description of these doors.

See the airplane Erection Manual for more detailed description of assembly of these sections.

C. Emergency Exits and Doors

Passage to and from the bomber's compartment is provided through hinged doors located in the bottom of the fuselage in the nose section. These doors are latched together at the center and swing outward when open. The handle installed in the left half is movable from either side and is pulled down to turn from without or pushed and turned from the inside. This door cannot be walked on; passage over it is accomplished by means of a combination grate and ladder hinged inside the fuselage. (See Fuselage Equipment, Section XIII.)

An emergency exit door operable from either side is also provided in the top of the fuselage immediately aft of the front turret. This door may be used as an escape hatch in event the airplane makes a forced landing on the bottom with the landing wheels retracted.

A passageway is provided through the fuselage from the nose turret to the pilot's cockpit. Drafts through these sections are reduced by means of a tight fitting canvas curtain containing a hinged door which is installed on the bulkhead aft of the lower front entrance door. The upper portion of the fuselage is closed against drafts by an additional curtain which is secured to the fuselage by button fasteners.

The bomb bay doors are described in Section XV.

A hinged door is provided in the bottom of the fuselage near section through which the bottom machine gun is operated. This door is operated from inside only and is equipped with a latch and handle for opening it inboard. Spring clip latches are installed on a cross bar in the fuselage above the door to retain it in the up position when the gun is in use.

D. Windows

A plate glass window is provided in the bottom of the fuselage in the radio compartment for using the drift sight meter. This window is mounted in a rigid frame which is hinged at the forward end so that it can be raised to clean the outer surface. A latch is provided to secure the window in place in the bottom and another latch on the bulkhead is provided for locking the window in the open position. When not in use, the window should be protected with a suitable pad.

CAUTION: ALTHOUGH THIS WINDOW WILL SUPPORT A HEAVY WEIGHT, IT SHOULD NOT BE WALKED ON SINCE AN UNSEEN CRACK MAY CAUSE IT TO GIVE WAY WHICH MAY RESULT IN INJURY

A window is provided for the radio operator in each side of the airplane near the floor and directly aft of the bomb bay. A small window is provided in the right side of the fuselage above the wing for the radio operator.

The rear gunner is provided with a window in each side of the fuselage opposite the bottom gun to increase the range of vision for that gun.

A long, curved, Plastacele window is installed in the nose of the airplane for bombing operations. It can be removed for replacement by taking out the screws which secure the frame. Electrician's rubber tape is used around the edges to prevent leaks and reduce deterioration. Cleaning is done in accordance with Paragraph F of this section.

E. Enclosures

The cockpit enclosures are shown in Figure 24C. This structure consists of a fixed section extended between the front and rear cockpits, sliding hatches for the pilot and co-pilot, and a collapsible streamline rear section aft of the rear cockpit.

A moulded, non-shatterable plate glass windshield is rigidly secured in a metal frame forward of the pilot. A rubber cushion is fitted over the edges of the glass in the frame to reduce possible failures. Replacements can be made by removing three countersunk screws at the bottom of the rear frame and by unscrewing the two rod connections in the top of the enclosure. The rear frame can then be removed and the glass taken out of the front frame. When replacing these panels, a leak proof joint at the frame may be had by applying "Bostik Universal Cement No. 292." This cement is a product of the B.B. Chemical Co., Cambridge, Massachusetts, U.S.A.

The pilots' cockpit hatch is a rigid framework of extruded aluminum alloy sections formed to the contour of the windshield. The frame is fitted with moulded plastacele panels secured in place when the frame structure is riveted together. Electrician's rubber tape is used to insulate the plastacele from the metal frame. A sliding, non-shatterable plate glass window is provided in the lower front panel at each side of the hatch with a finger hole in each for opening. A latch and handle is provided at the top left side of the hatch, which can be operated either from the cockpit or from the outside. The hatch is mounted on three pairs of grooved rollers at each side which guide it along a track installed on each side of the fuselage. Holes provided at intervals along the track permit the hatch to be locked partially open.

The hatch is removed from the airplane by taking out the screws which hold the top rollers in place, and then slightly springing the frame far enough to lift the hatch clear. The plastacele panels can be replaced by disassembling the frame by removing the necessary rivets.

The co-pilot's hatch is constructed similar to the forward hatch except that it has no separate sliding panels. The method of mounting, operation, and latching at various open positions is the same.

The center or fixed section enclosure is constructed similar to the movable hatches having clear transparent plastacele panels throughout, secured in a metal frame. The sections of this enclosure are more easily replaced since the metal structure is assembled with screws and Elastic Stop Nuts. A removable panel is secured in position on the left side of this section enclosure by means of Dzus cowl fasteners. Access to the bomb bay fuel tank filler neck is had through this panel opening.

The installation of the radio mast through the top of this fixed enclosure (Figure 68) necessitates a leak proof joint around the plastacele. This condition is obtained by applying "Bostik Universal Cement, No. 292" around the rubber socket on the outside of the enclosure.

The rear streamline section of the enclosure consists of tapered panels hinged together as shown in Figure 24D. This assembly is equipped with a hinged tubular support and sliding handle with which the enclosure can be folded down against the top of the fuselage thus providing clearance for operating the rear gun.

To lower the section, move the machine gun forward if installed, and draw the operating handle toward the operator. To raise the enclosure, it is necessary to lift the center panel with one hand while pushing the operating handle with the other. A latch and hook are provided to secure this section in the folded condition as shown in Figure 63.

F. Maintenance

When the Plastacele windows have become soiled with grease or oil, solvents for these substances, such as kerosene or naphtha, may be used to remove the dirt. See list of compounds, Appendix IV. Solvents, such as esters, ketones, aromatic hydrocarbons, or chlorinated hydrocarbons must not be used as cleaners. Cleaning should be done with a damp cloth and care must be taken not to rub hard particles of sand or grit into the surface. The surface should then be rinsed with mild soap and water and then wiped lightly with a soft cloth.

Badly scratched surfaces may be polished with a soft felt disc turning at a low speed (250-500 rpm) and wet with a paste made from magnesium carbonate or "Tripoli" and water. Care must be taken to keep the polishing wheel moist and not to apply too much pressure to the piece being polished since heat generated by friction will leave the surface full of ridges.

Celluloid or similar materials should not be substituted for the transparent "Plastacele." The rivets which attach the "Plastacele" panels are aluminum and the heads may readily be chipped off when replacing the panels. It is important that the spacers used on these rivets be replaced in order to prevent clamping action, which may cause the material to crack due to expansion or contraction caused by temperature changes. Except for the "Plastacele" panels, non-shatterable plate glass is used on these enclosures, and it is important that this glass be floating in rubber in order to eliminate breakage due to strains and deformations of the supporting frames. When new glass is installed, the same rubber moulding that is now around the glass or its equivalent should be used.

The fuselage itself should require little maintenance except to be kept clean and repainted when the protective coatings have worn off. In case of damage to the smooth covering, repairs should be made as described in Appendix I.

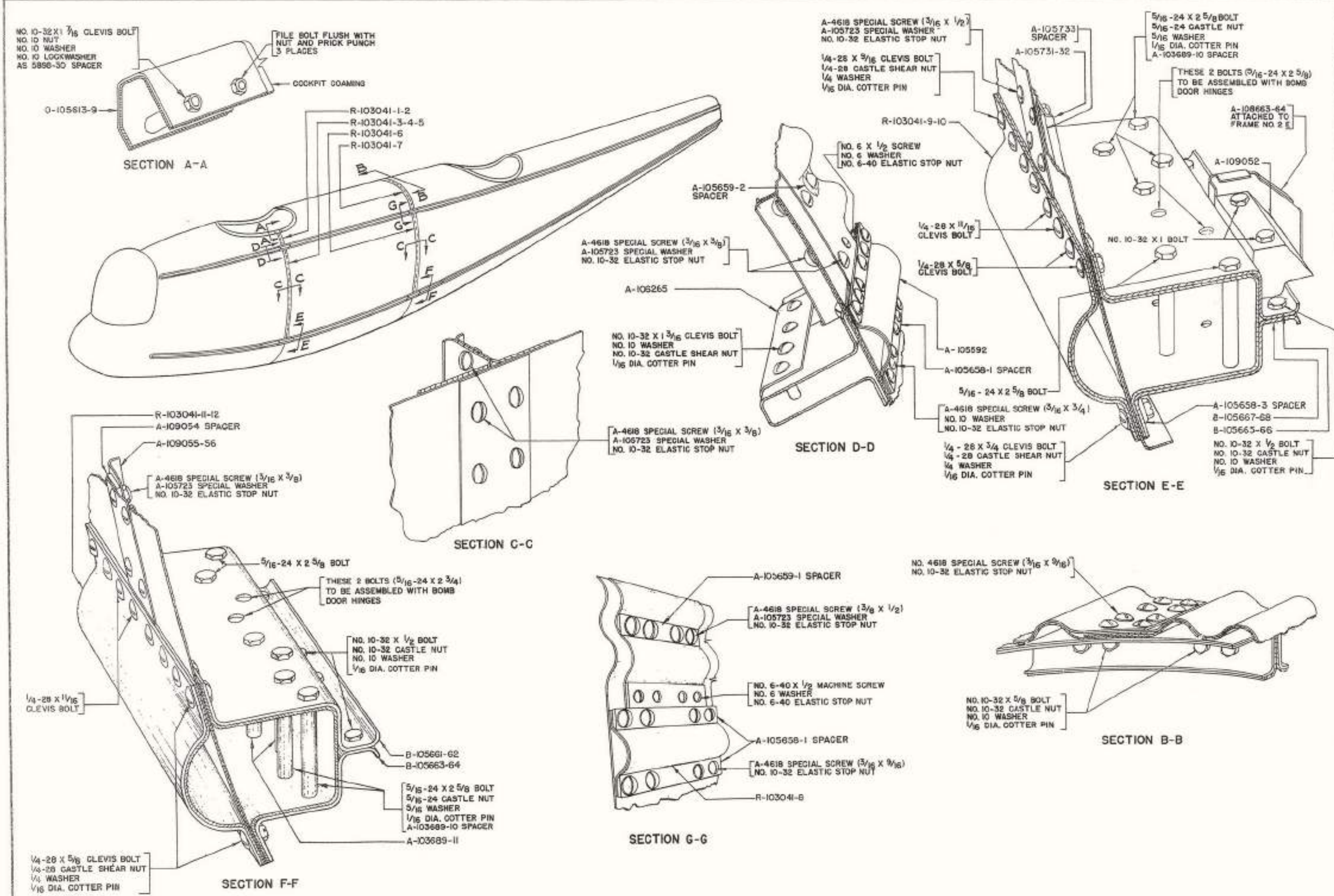

FIGURE 22 MODEL 139-W FUSELAGE SPLICE DIAGRAM

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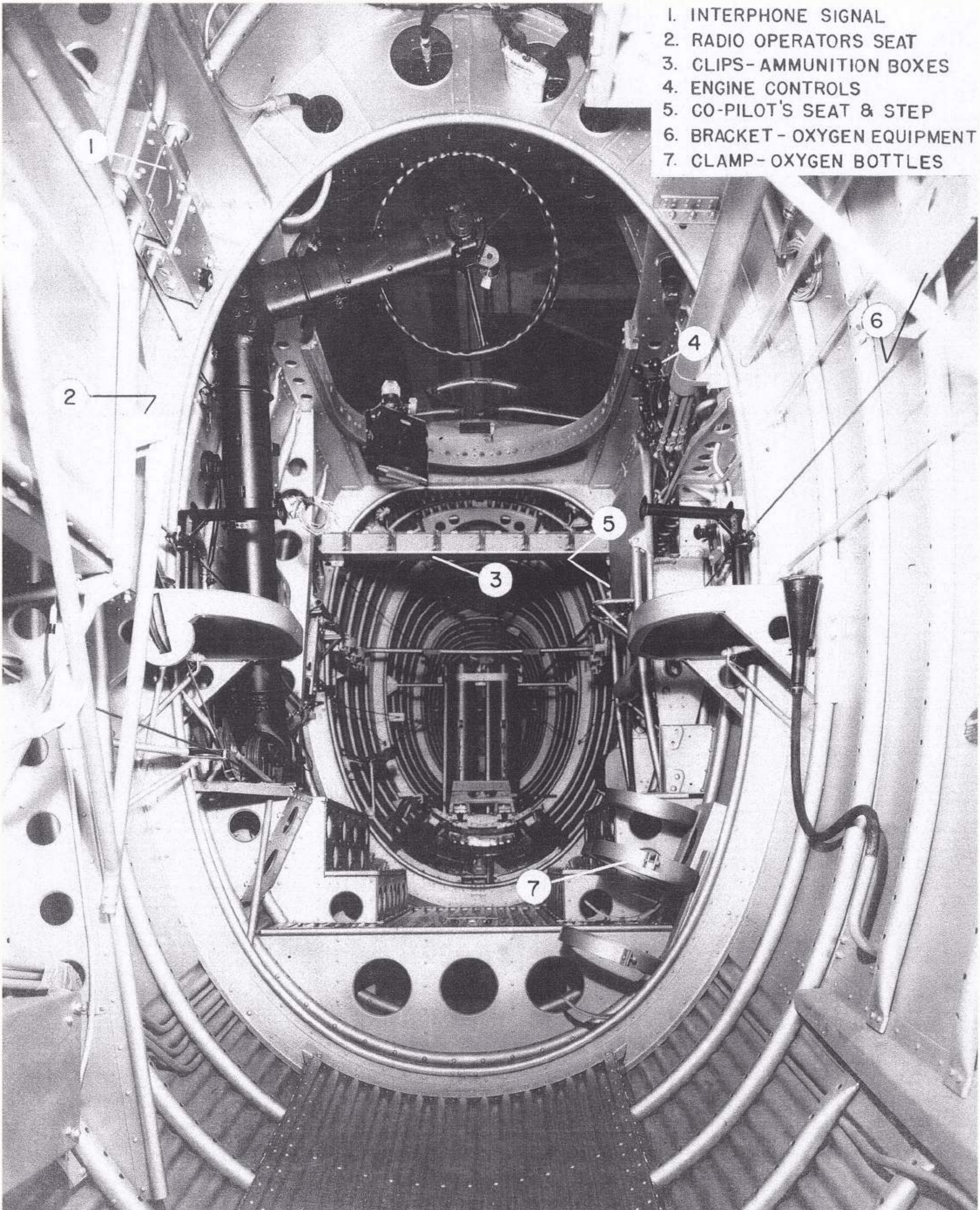


FIGURE 23 FUSELAGE - TYPICAL TAIL SECTION - LOOKING AFT C

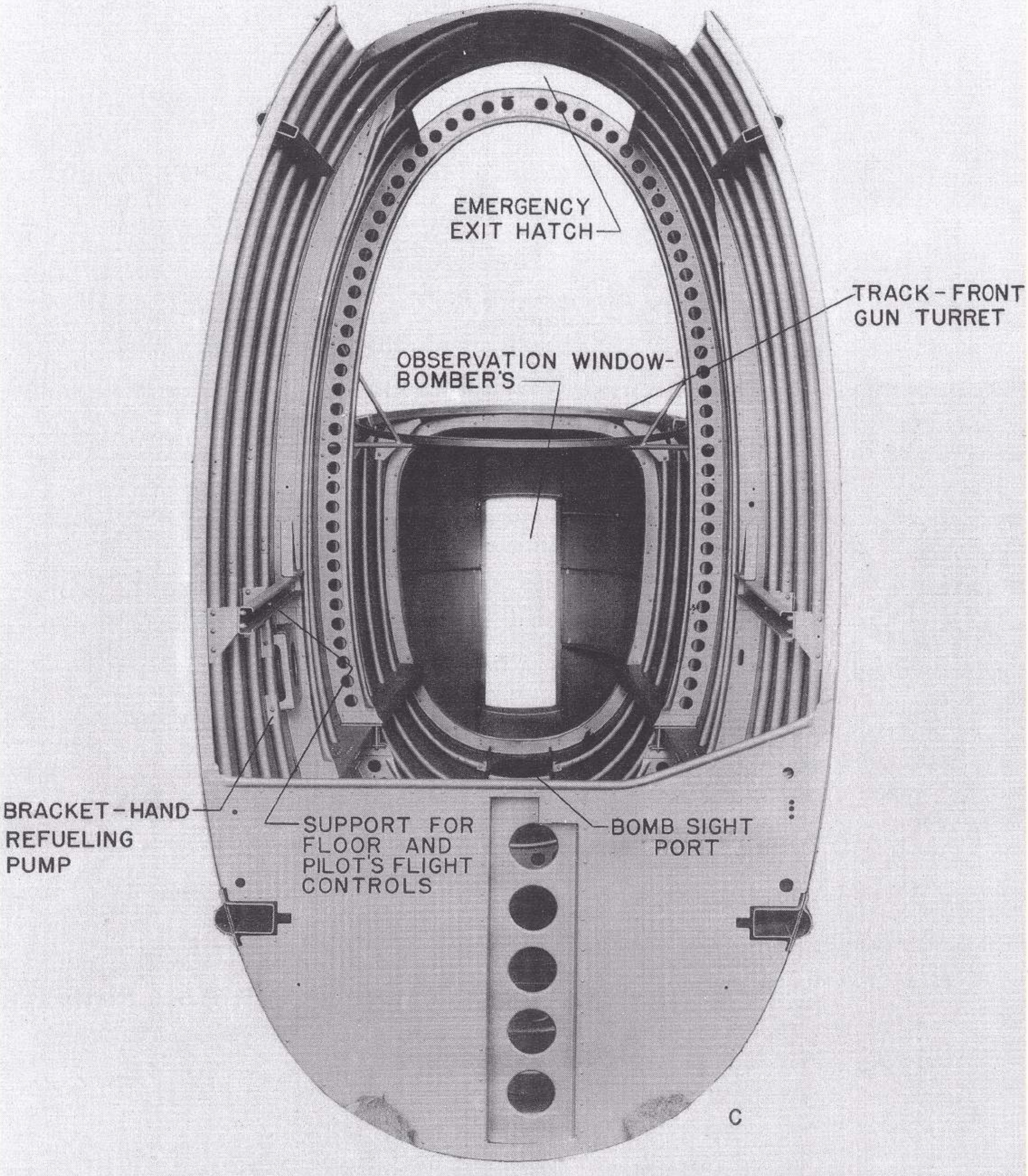


FIGURE 24. FUSELAGE STRUCTURE - FRONT SECTION - LOOKING FORWARD

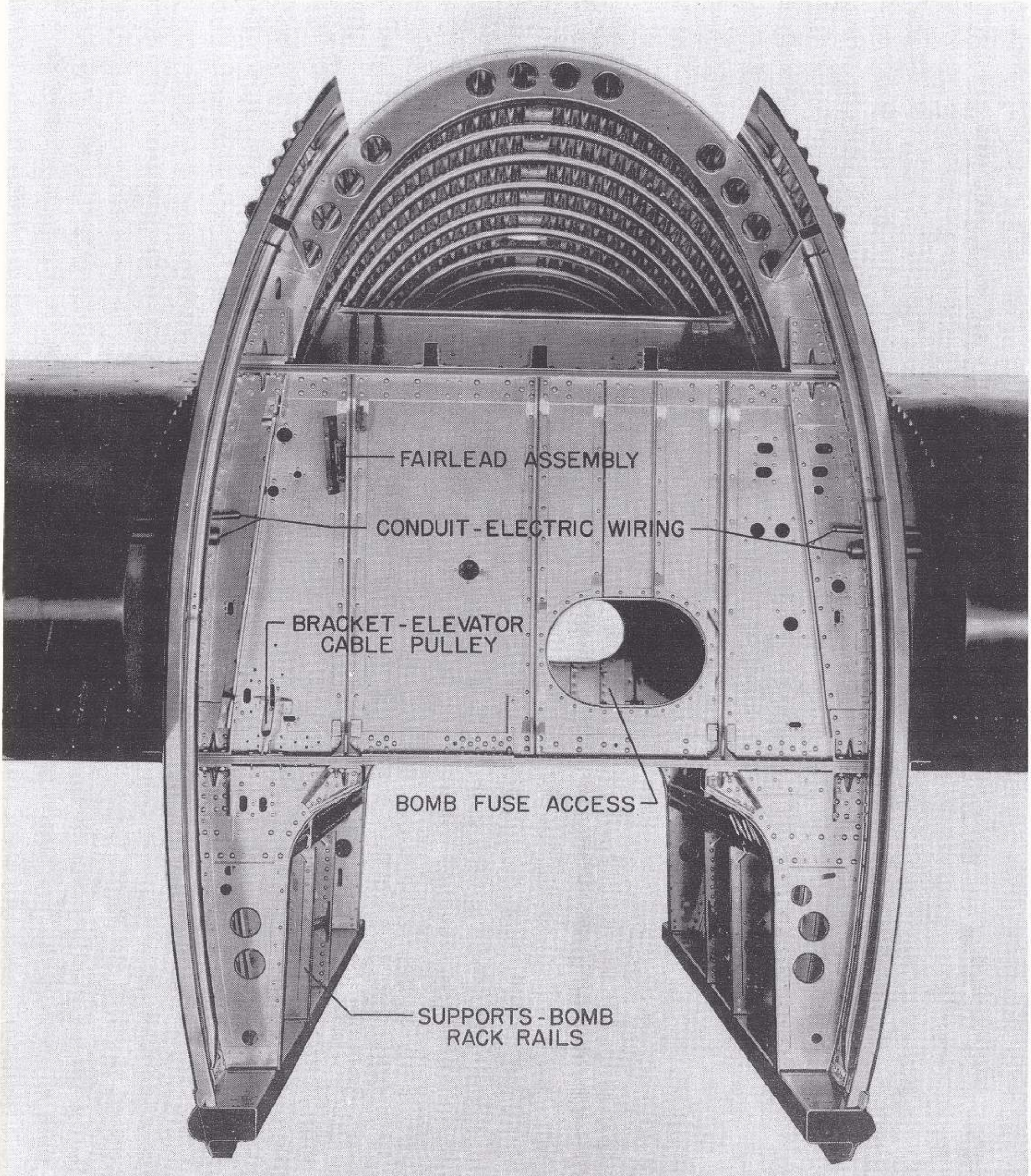


FIGURE 24A FUSELAGE STRUCTURE-CENTER SECTION-LOOKING AFT

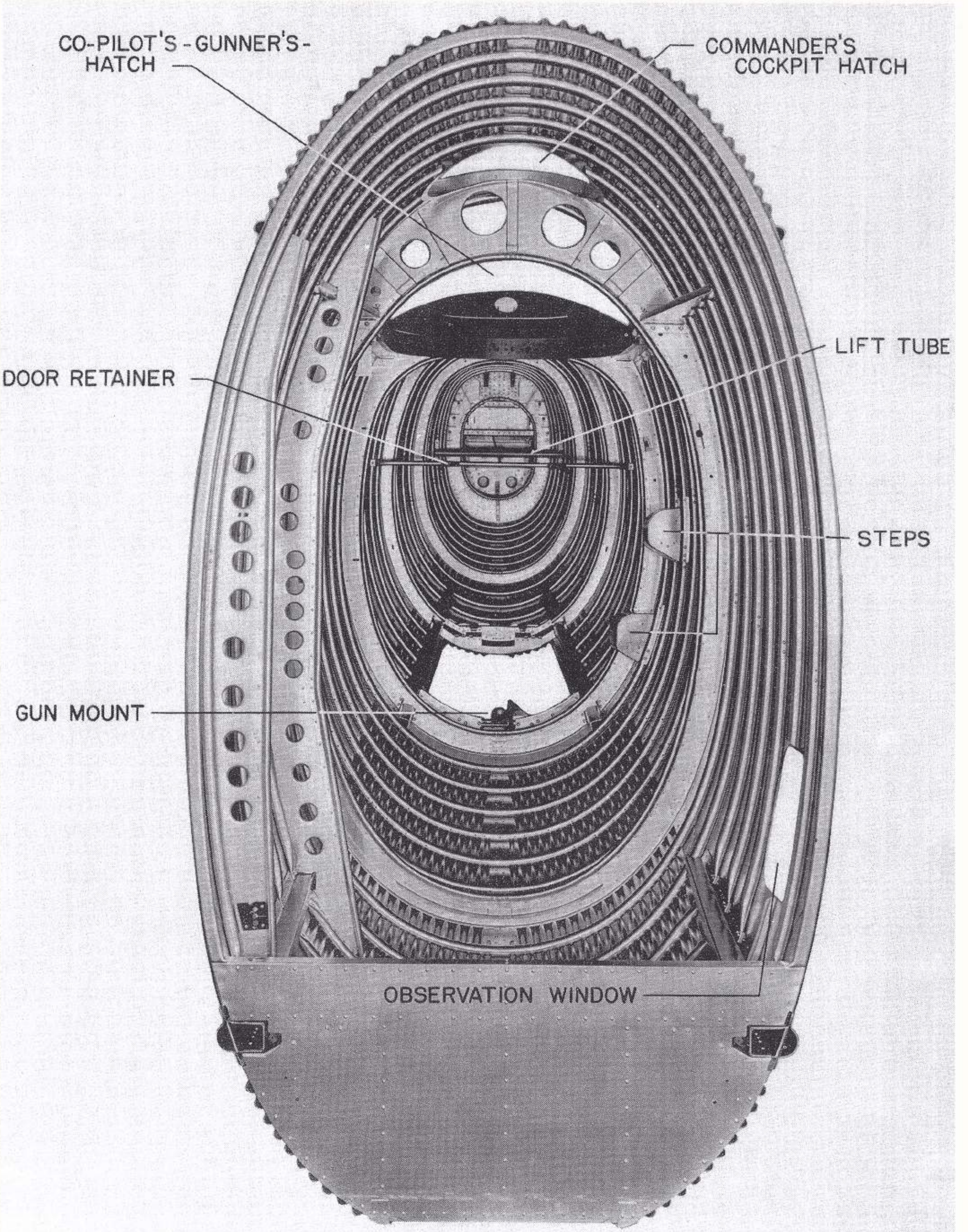


FIGURE 24B FUSELAGE STRUCTURE - TAIL SECTION - LOOKING AFT

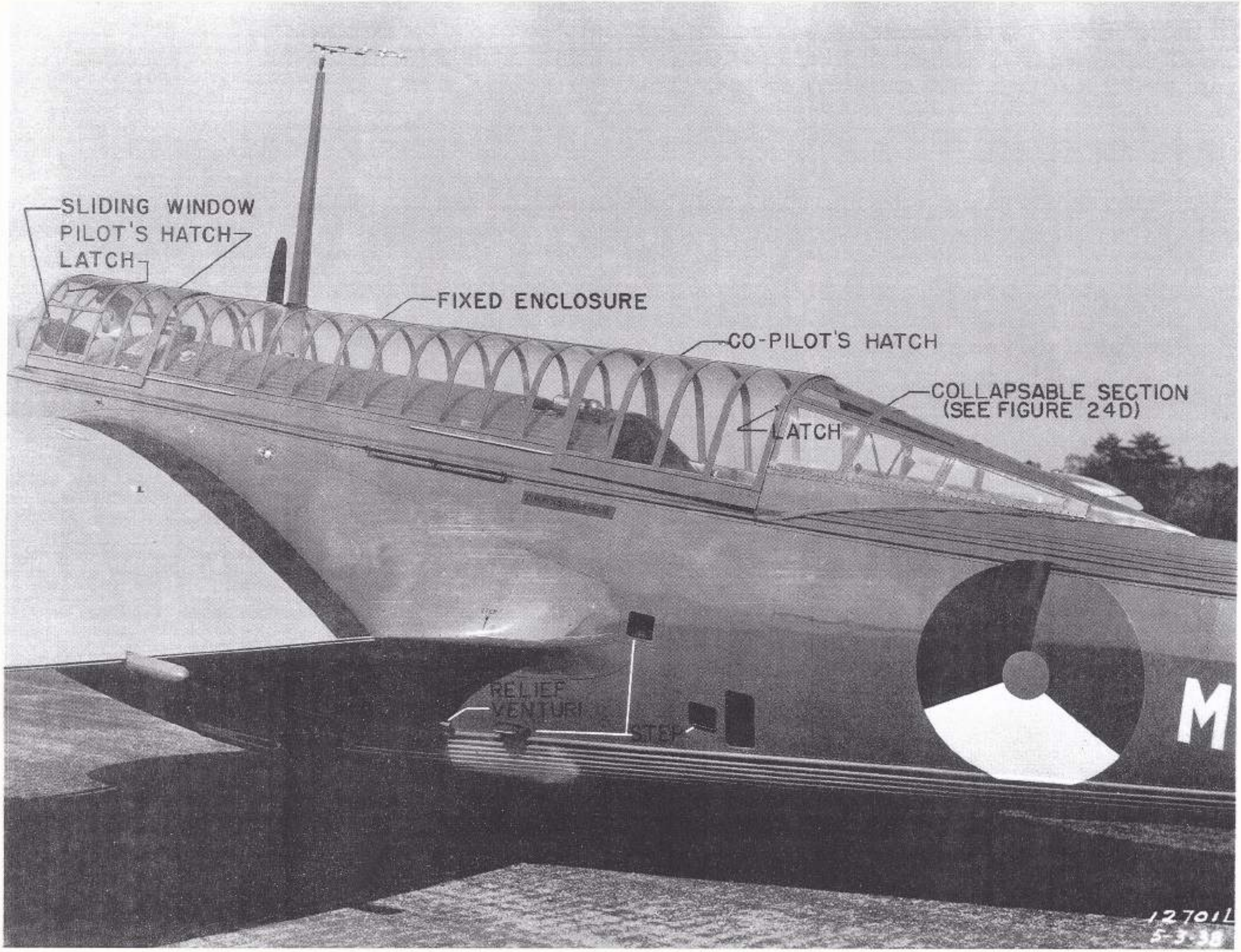
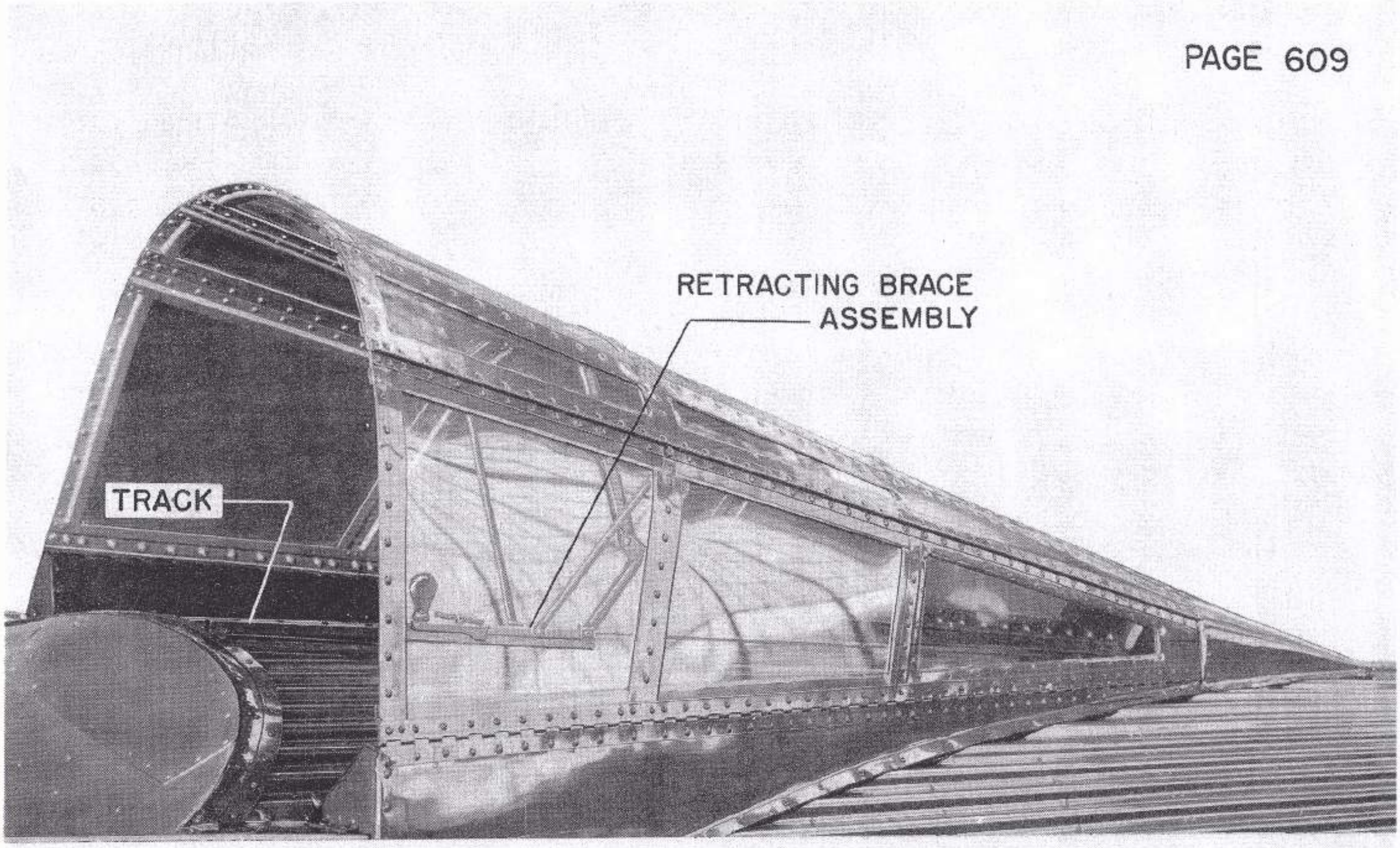


FIGURE 24-C COCKPIT ENCLOSURES



FOR ENCLOSURE HOOK RETAINER SEE FIGURE 63

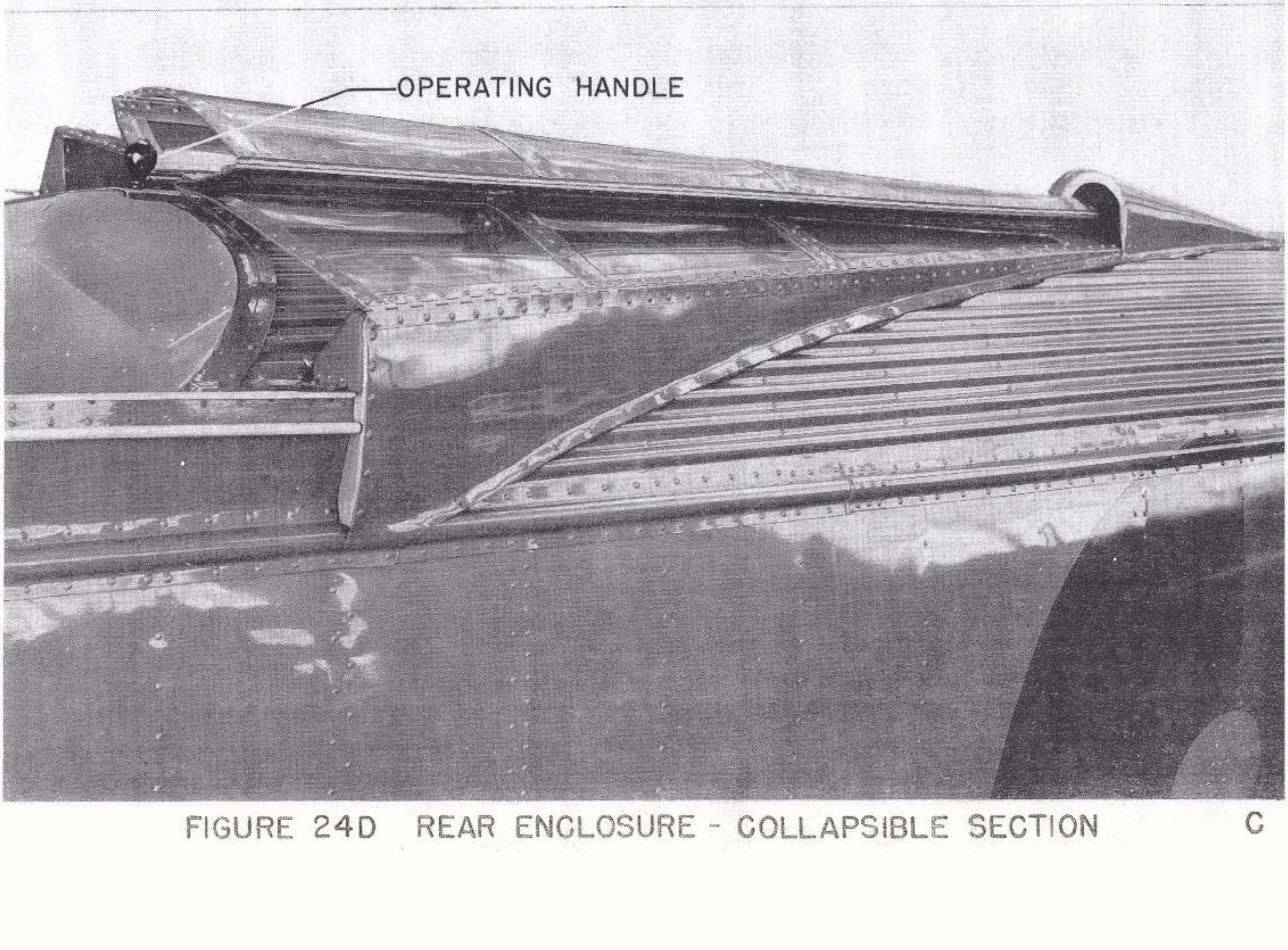


FIGURE 24D REAR ENCLOSURE - COLLAPSIBLE SECTION

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SECTION VII

TAIL WHEEL

A. Description

The tail wheel assembly is of the cantilever, half fork type, as shown in Figs. 25 and 26. The half fork is held in a "V" shaped built up steel hanger, which carries the swivel bearings and anti-shimmey assembly. The Cleveland Penumatic shock strut No. B-187M, is attached to the hanger forward of the upper swivel bearing by a unilink and two 1/2-20 bolts. The upper end of the shock strut and the base of the hanger are bolted by one 1/2-20 bolt, and two 3/8-24 bolts, respectively, to three fittings attached to the rear fuselage bulkhead. The wheel is free to swivel 360° with any shock strut deflection. Instruction plates for the shock struts are attached to the strut and to the L.H. inspection door on the empennage tail fairing.

B. Assembly

The wheel, half fork, steel hanger, and unilink assembly are installed independent of the Aerol Strut with two 3/8-24 bolts. The aerol Strut is attached to the unilink and upper fuselage fitting by 1/2-20 bolts.

C. Maintenance

For the best condition of landing, the tail wheel tire should be deflected 1-3/8 inches, under static load. This deflection can be easily determined by measuring the distance from the ground to the center of the axle. This dimension should be 5-1/4 inches, and should be checked daily.

At regular twenty hour periods, lubricate four Zerk fittings with grease, A.C.Spec.VV-G-681 and check the following:

1. Inspect fittings on the rear fuselage bulkhead for fracture. This is accomplished by removing the rear end of the empennage fairing.

2. Inspect attaching bolts, and see that they are securely cottered.

3. If at any time the tail wheel is disassembled, the retaining nut at the top of the fork should be tightened down, when replaced, only far enough to insert the cotter pin.

4. Inspect and service Aerol Strut as follows:

To check the fluid level, airplane must be in three point position.

1. Remove valve cap.

2. Depress valve stem until air has been released, and strut is fully compressed.

3. Remove valve body and fill strut cylinder to valve level with a mixture of Butyl alcohol and castor oil. (Paragraph I, Sec. IX).

4. Replace valve body securely, making sure that the gasket is in good condition.

5. Inflate strut to proper position and replace valve cap.

If there is an indication of oil leakage, release air pressure, as per instructions, and remove lock wire and tighten gland unit. Replace lock wire, check fluid level and inflate strut.

WARNING: Release air in strut before disassembling.

To Inflate Strut

1. Remove valve cap and attach air hose.

2. Inflate strut until red line is 2.5 inches (6.35 cm.) from packing gland. Move plane forward several times while inflating, to allow wheel to take its normal position. This same inflation is recommended for overload condition.

3. Replace valve cap and tighten securely.

For additional information on inspection and maintenance instructions of strut, see data under Shock Struts, Section IX. See Section XXIII for additional inspection of tail wheel.

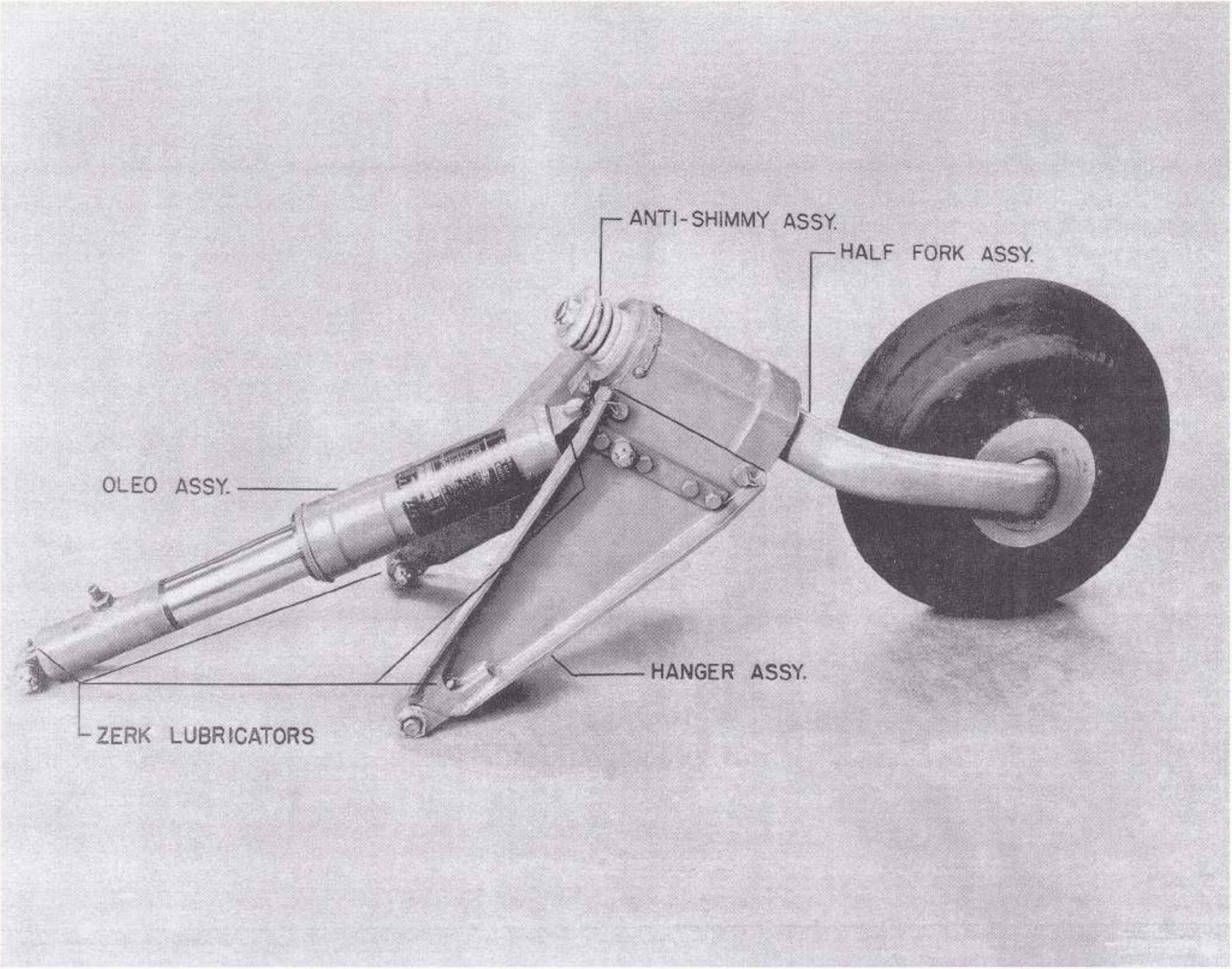


FIGURE 25 TAIL WHEEL ASSEMBLY

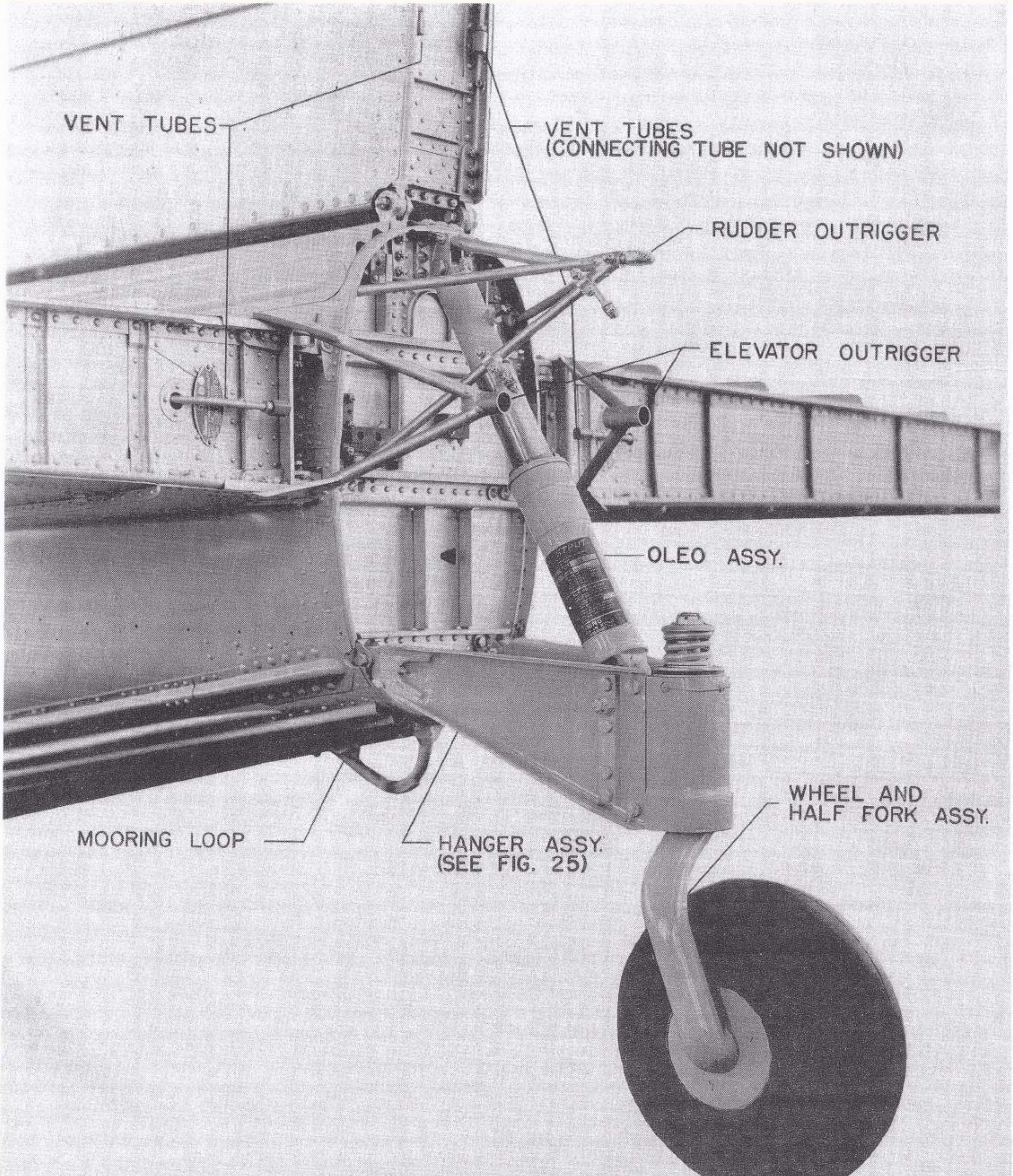


FIGURE 26 TAIL WHEEL INSTALLATION

NACELLES

A. Description

1. General

The engine nacelles consist of a tubular steel engine mount, Figure 27; a corrosion-resistant sheet steel venturi cowl support and muff assembly, Figure 29C; the engine cowling, Figure 28; and the venturi cowling, Figure 29. The complete installation of the cowling sections is shown in Figure 29A.

The nacelles comprise a demountable part of the center section wing and may be removed completely except for the cowling from the airplane. The nacelles are interchangeable in their corresponding positions from one airplane to another.

2. Engine Mounts

The engine mount frames are constructed from 4130 steel tubing (A.C. Spec. 57-180-2) reinforced with special U shaped gussets welded around the intersection of the frame and the engine ring. The entire structure is assembled by torch welding and is sand-blasted to remove the scale formed by welding. The completed welded frame is filled with hot linseed oil, drained, and hermetically sealed by driving self-tapping screws into the holes provided for checking the entrance of oil into the various legs of the mount. A drain plug is provided in the gusset at the juncture of the upper left brace tube with the engine ring.

The engine mount attaching fittings are machined for a maximum bearing surface against the mounting pads on the front wing spar. These surfaces must be clean and free from burrs when the engine mounts are put in place. An AN-310-8 steel castle nut is used on each of the two lower fittings, and an AN-310-9 steel castle nut is used with an AN-360-9-16 plain steel washer on each of the two upper fittings to secure the mount to the spar. Steel cotter-pins are used to lock the nuts.

As shown in Figure 27, brackets are welded to the engine ring for attaching the Lord "Tee" type engine mounting bolts. Additional brackets indicated by 1 in the Figure and located equidistant around the ring are used to support the engine muff assembly. The three brackets indicated as 2 are used to support the cowl flap control mechanisms as shown in Figure 29-C.

B. Venturi Cowl Supports and Muff

1. Description

The muff assembly is constructed in two sections of formed corrosion-resistant sheet steel, A.C. Spec. 57-136-9. This assembly, Figure 29-D, is symmetrical in construction, having an integral, formed recess or "well" section terminating in a flange at the outer rear periphery. This flange, shown in Figure 41, serves as a support for the venturi cowl. The exhaust manifold is confined within the "well" formed by the muff and the sections of the venturi cowl when the latter is installed in place.

A one-half inch gap is provided between the outer edge of the muff front plate and the venturi cowl when they are assembled together. This gas permits the entrance of cold air into the manifold "well." Two air outlet ducts, part of the carburetor air preheater assembly, are bolted to the top rear side of the muff in order to facilitate the escape of heated air from the "well" into the preheater assembly. See Air Intake System, Paragraph F, Section X.

2. Installation of Muff

During normal maintenance operations, the muff sections should be assembled together and installed on the engine mount before the engine is put in place. However, should it be necessary to remove or install the muff with the engine in place, it will be necessary to disassemble from the airplane such parts as the exhaust manifolds, carburetor, and heat control valve, engine cowl flap controls, magneto blast tubes, and the exhaust gas analyzer. See Figures 29-C and 43. Refer to Section X for information on these units.

The two sections of the muff are assembled together at the horizontal centerline with No. 10-32 steel bolts through the flanges and faying surfaces. Flat steel nuts and lock washers are used. The muff is secured to the brackets on the engine ring with No. 10-32 steel bolts, plain washers, and castillated nuts.

C. Venturi Cowling Assembly

1. Description

The venturi cowling is constructed from Alclad Aluminum Alloy sheet, reinforced on the inner side with formed channels and flanged angle sections. Spot-welding is used wherever possible in fabricating. All external rivets used are driven flush with the skin. The cowling is composed of six removable sections assembled circularly around the engine nacelle forward of the wing leading edge, tapering aft to fair into the wing.

Aft of the leading edge the cowling is faired by a fixed top section, and two sections of removable cowling which locate around the wheel well. Excepting the top rear fairing, all sections are secured to the nacelle and wing by means of Dzus cowl fasteners. The top rear section is permanently riveted to the wing and should never be removed. Access to the oil tank filler neck which is located under this fairing is provided through a hinged door at the rear. A Dzus fastener is used for latching. Two covered holes provided immediately aft of the fire-wall in this fairing permit access to the pipe connections in the oil lines. The covers are secured with No. 10-32 washer-head screws and fiber-lock-nut plates.

In order to minimize the leakage of hot air from the muffwell into the nacelle, a woven asbestos seal is provided on the aft side of the cowl support section of the muff, and bears against a flange provided on the inside of the cowl sections (see Figure 41). Any air passing into the nacelle is permitted to escape through a one-half inch gill opening provided at the lower rear edge of removable cowl sections.

2. Installation of Cowling

The top section of the venturi cowling is fitted around the carburetor preheater and it cannot be removed or installed with the top section of the engine hood cowl in place. The remaining five sections are removable after the engine cowl flaps are extended open. Any of these five sections can be removed separately.

It is extremely important that the Dzus cowl fasteners used to secure the cowling in place be completely locked when the cowling is installed. A thick ended screw-driver or other suitable tool may be used.

When handling the cowl sections, care should be exercised against dropping or otherwise damaging the pieces in order to insure a good fit and to maintain the 1/16 inch gap required at the abutting edges of the sections.

D. Engine Hood Cowl Assembly
1. Description

The hood cowling consists of three interlocking sections constructed from Alclad aluminum alloy sheet. A rolled tube having plug terminals at each end to facilitate joining the sections is riveted to the leading edge of the cowling to provide rigidity Additional reinforcement is provided by a rolled channel installed between the leading and trailing edges, and by a formed flanged angle at the trailing edge. Spot-welding and flush riveting used throughout this assembly provide a smooth outer skin surface

The top section of the engine hood cowl is equipped with a permanent integral air duct which supplies cold air to the carburetor preheater. A baffle plate is constructed at the aft end of the air duct which bears against a special gasket on the preheater assembly to reduce leakage at this point. See Air Intake System, Paragraph F, Section X.

The engine hood cowling sections are supported on the engine by two formed channel rings which are attached to the lugs on the engine rocker boxes by means of "Lord" type rubber vibration absorber units. The front ring is more rigidly attached to the engine by twelve Lord units since it is used to locate and retain the cowling in the fore and aft position. This is accomplished by inserting the intermediate former ring on the cowling sections in the front channel. The rear support ring is attached to the engine cylinders with six Lord units. Loads due to vibration and to expansion (due to heat generated while running the engines) are taken up by these rubber mounts. (The front ring must be installed with the small cut-outs facing forward.)

The top section of cowl is located by means of a pin provided in the top of the front support ring. An additional pin provided on the cowl former directly behind the front pin socket keeps the hood cowling from rotating about the engine. Phenol fiber chafing strips are riveted to both rings to reduce wear on the faying surfaces.

The three sections of the hood cowl are assembled together at the two top joints by means of overlapping steel terminals which are locked by special pins inserted through the terminals, then turned fore and aft. When all three terminals at either joint are locked together, the pins are secured against turning to the unlocking position by installing an external gap-cover strip equipped with three slots over the pins. Dzus cowl fasteners retain the gap covers in place. The pins are secured to one section of the cowling by steel cables.

The bottom joint is drawn together with three special adjustable trunk-type toggles. Safety pins are provided with which the toggles are secured from releasing by vibration. It is very important that these safety pins be properly attached and that the two top gap covers be installed when the cowling is in use.

E. Engine Cowl Flaps
1. Description

The engine cowl flaps are a separate and independent installation which function as a part of the engine hood cowl trailing edge, and provide a variable throat between the engine hood cowling and venturi cowling. When used for cooling the engine the flaps are extended radially outward from the axis of the engine by means of a cable-operated control mechanism operable from the pilot's cockpit.

The flap sections are fabricated from Alclad aluminum alloy sheet riveted and spot-welded together. The gaps between the metal sections are closed with a thin phenol fiber cover plate inserted between adjoining sections. It is essential that the grooves in which the fiber gap covers operate be kept cleaned of dirt accumulation to permit complete closing of the flaps.

2. Cowl Flap Operating Mechanism

The rear support ring for the engine cowl is also used to attach the flap sections as shown in Figure 29-C. The flaps are interconnected by hinge brackets as shown in the figure so that any movement of the three master flap sections causes all the sections to move simultaneously. Movement of the flaps is accomplished with three push rods connected between the master flap sections and three interconnected worm-gear assemblies which are installed on the engine mounting ring aft of the muff. The two upper gear units are operated by the bottom unit through universal torque shafts which are supported in bronze bearings on the rear side of the muff. The push rods are operated in each case by a lever bolted to the rear shaft of the worm-gear units forward of the muff. Stop levers on all three worm-gear mechanisms must be against their respective stops simultaneously when the flaps are fully closed.

The bottom gear unit is equipped with a grooved drum on which the operating cables extending to the pilot's controls are wound. Refer to the Cowl Flap Control Drawings (see drawing list in Appendix III).

The control mechanism in the cockpit is clamped to the control column directly below the wheel. The left and right-hand flap operating cables are wound on drums supported by two shafts in this assembly. A single handcrank is geared to both shafts, either one of which can be operated independent of the other, or both together as desired. Independent operation of either engine flap is controlled by the corresponding fiber knob provided at each side of the handcrank. Turning the knob down in a clockwise direction causes the drum shaft to be connected to the gears through friction. Turning the knob in the opposite direction as far as possible will free the drum shaft from the gears. Since this mechanism depends on a dry friction drive, no oil or grease should be applied to the gears. Self lubricating bearings are used throughout, and a very light coat of hard graphite grease is applied to the teeth of the steel gears at the initial assembly. This lubricant should be sufficient to last indefinitely.

3. Cable Installation

Flexible tinned cable (size 7x7x1/16 inch) is used throughout the system. When installing new cable, the instructions outlined below should be followed:

(a) Cables lengths are called for on the drawings and designated on the Flap Control Drawing as (-1), (-2), (-3), (-4). Cables (-1) and (-3) are used in the left-hand installation.

(b) Cables may be laid over either pulley in brackets provided between the cockpit and engine nacelle; except at the control column where a definite location is necessary. Cables should be crossed only where necessary. The installation throughout the the fuselage, wings, and nacelles should be made before assembling the cables with the drums. The cables from the right-hand flaps pass through the fuselage along the front side of the wing spar to the left side of the fuselage and parallel the left-hand cables to the control column. The lower pulley sets in the fuselage are used for the right-hand cable installation. At the control column the left-hand (-1) or "opening" cable must pass over the front pulley of the top pair which are located at the end of the column under the floor. The right-hand (-4) or "closing" cable must pass over the rear pulley of the lower pair located at the end of the column.

(c) The tension-adjusting assembly which is located adjacent to the nacelle in each wing should be left loose until final adjustments are made.

(d) Cables are installed on the drums as follows:

Dash No.	To	Purpose	Installed On
-1	Left Eng.	Flap Opening	Bottom of drum in Eng. Nacelle to top inboard side of drum in Cockpit.
-2	Right Eng.	Flap Opening	Bottom of drum in Eng. Nacelle to bottom outboard side of drum over idler pulley in Cockpit.
-3	Left Eng.	Flap Closing	Top of drum in Eng. Nacelle to bottom outboard side of drum over idler pulley in Cockpit.
-4	Right Eng.	Flap Closing	Top of drum in Eng. Nacelle to top inboard side of drum in Cockpit.

(e) The cable connection with the drums should start at the nacelle drum. The following instructions cover the rigging of the flaps in the closed position. Since there are no turnbuckles in this installation to take up slack, the initial assembly should be made as carefully and as tightly as possible.

(f) Rotate the push-rod lever in the nacelle to the vertical "UP" position. Remove the drum attaching bolt and slip the drum off the shaft.

(g) Insert the end of the (-1) cable through the hole in the web of drum from the right leaving approximately 2" protruding for anchoring. Slip the cable into slot and wind approximately 20 turns of cable on drum, turning the drum onto cable to prevent twisting of the cable. Wrap cable and drum with friction tape to prevent cable from unwinding.

(h) Replace drum on shaft making certain that the slots in the drum are at the top. Insert cable end into upper hole of the cable clamp, and draw up temporarily.

(i) Remove the pulley guard from the crank assembly in the cockpit. Secure the drum against turning by tightening the friction lock knob on the crank assembly.

(j) Wind the (-1) cable approximately 1 turn over top inboard side of left cockpit drum beginning in the second groove from rear end of drum. Insert cable in slot and thread through hole in web of hub and through top hole in cable clamp. Remove slack in cable during this operation.

(k) The (-3) closing cable can now be connected at the nacelle unit, as that end must be connected first. Since the first cable is now completely assembled, the friction tape can be removed from the nacelle unit drum. The end of the cable can be inserted between the drum and cable guard, wound one turn around the drum in the groove remaining at the outer end. Thread end through slot and wrap half turn around hub and thread through bottom hole of cable clamp. Straighten out cable and anchor securely.

(l) By turning the crank in the cockpit (to open), the (-1) cable will be unwound from the drum in the nacelle permitting the (-3) cable to be wound onto the drum in its place. The (-3) cable should be held tight during this operation.

(m) Final assembly of the (-3) cable in the cockpit is next made. Draw the cable through the airplane to remove slack. Place cable over idler pulley located below drum and wind over top of drum in the groove remaining at the forward end. Insert cable in slot at top of drum, wrap 1/2 turn around drum hub, and through bottom hole in clamp.

(n) Any excessive slack remaining in the cables can be removed by operating the system both ways a number of times, tightening up the ends at the clamps as required. (Final slack may be removed later when tensioner pulley assembly is tightened up.)

(o) When sufficiently tight, clamp securely and safety the nuts. Cut cables off approximately 1/4 inch from ends of clamp, spread the ends open with a screw driver and solder the frayed ends to permanently lock.

(p) As a final adjustment, turn down the nut on the cable tensioner in the wing only enough to provide a taut cable through the complete fore and aft movement of the control column. It is essential that the spring in the tensioner is not completely compressed.

(q) The right-hand cable assembly is made in a similar manner, referring to the chart in Paragraph 4 to ascertain the direction and location of the cables.

(r) The push-rod connection from the lever to the bracket on the master flap sections is made and adjusted at the terminals. In the normal closed position the flaps will be approximately parallel to the centerline of thrust or faired in a straight line with the engine cowling. Fully closed they should retract inboard toward the center approximately 5° (or 3/8 inch. approximate "gill" opening). Fully opened they will extend approximately 45° from normal closed position, the full travel being approximately 50° from full open to full closed.

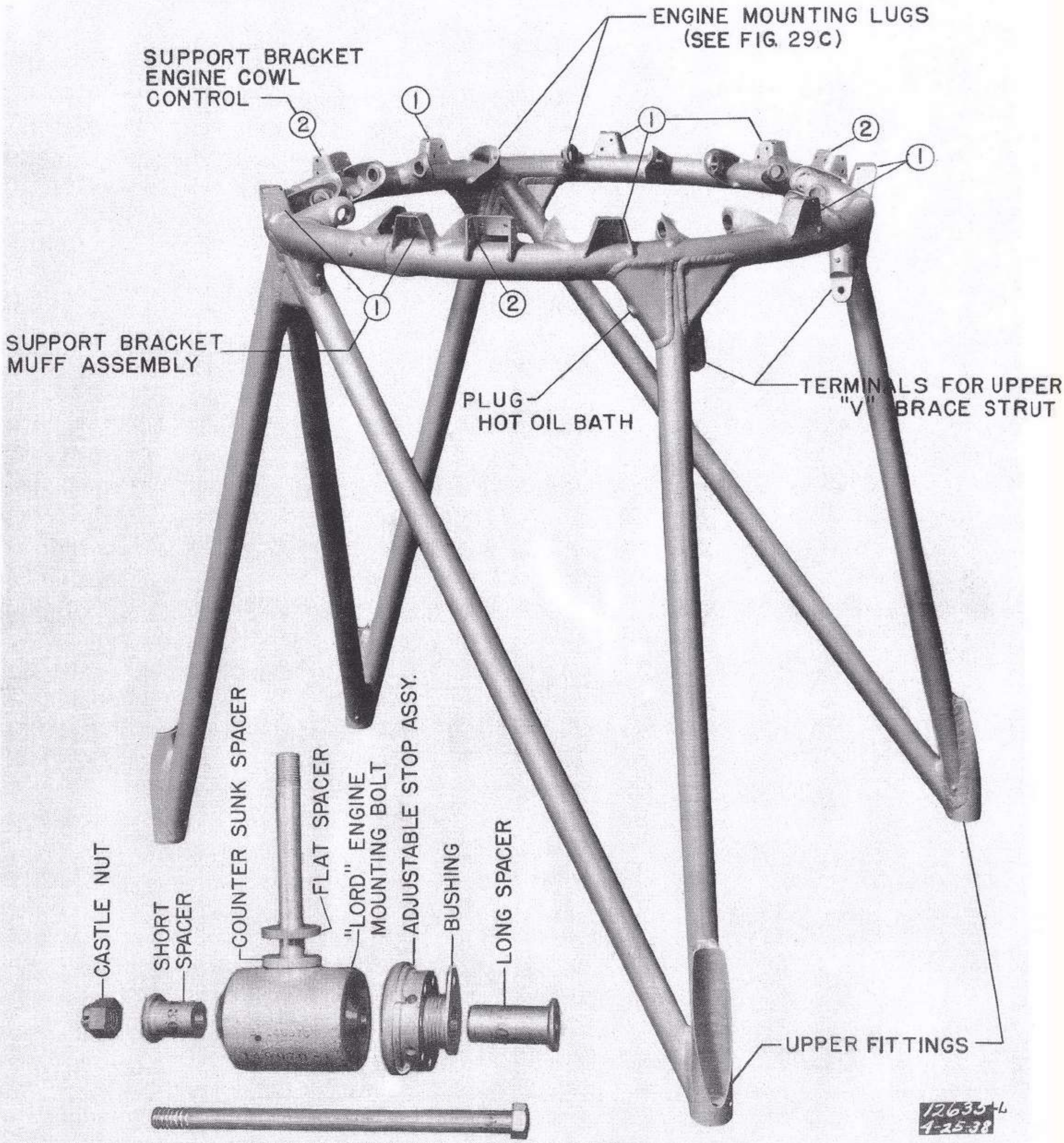
Details of the operation of the flaps on the ground and in flight are given in Section II-A (Maintenance Manual).

F. Maintenance

The engine mounts are detachable and are interchangeable to facilitate maintenance and repair. Whenever practicable, the engine should be removed from the mount when repairs to the structure are necessary. Welding on the structural tubular members of the engine mount is not recommended, and failure of any member will necessitate the replacement of the complete mount.

Alclad aluminum alloy sections may be repaired in accordance with the instructions given in Appendix I of this manual. Spot-welded sections may be repaired wherever failures can be cut away and the reinforcements replaced by riveting.

Frequent inspection of cowling fasteners, latches and vibration-absorber mountings will aid in keeping the assemblies in good condition. The tension of flap cables should be checked at regular intervals; and changed when necessary. Keep the recesses at the flap sections clean to permit the phenol fiber gap strips to close properly. (See Section XXIII for additional inspection procedure.)



SEE ENGINE INSTALLATION DRAWING FOR PART NUMBERS

FIGURE 27 ENGINE MOUNT ASSEMBLY

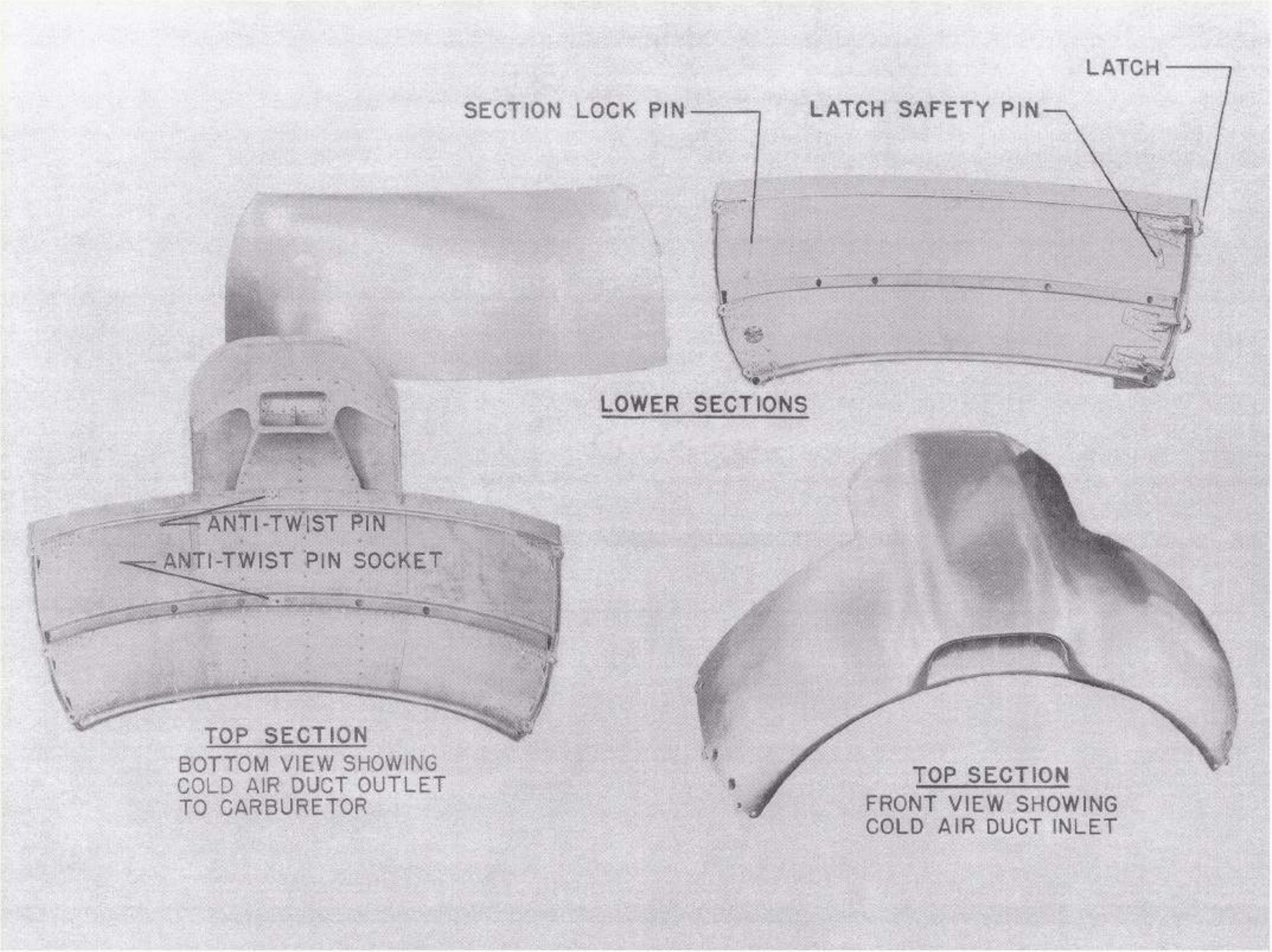


FIGURE 28 ENGINE HOOD COWL COMPONENTS

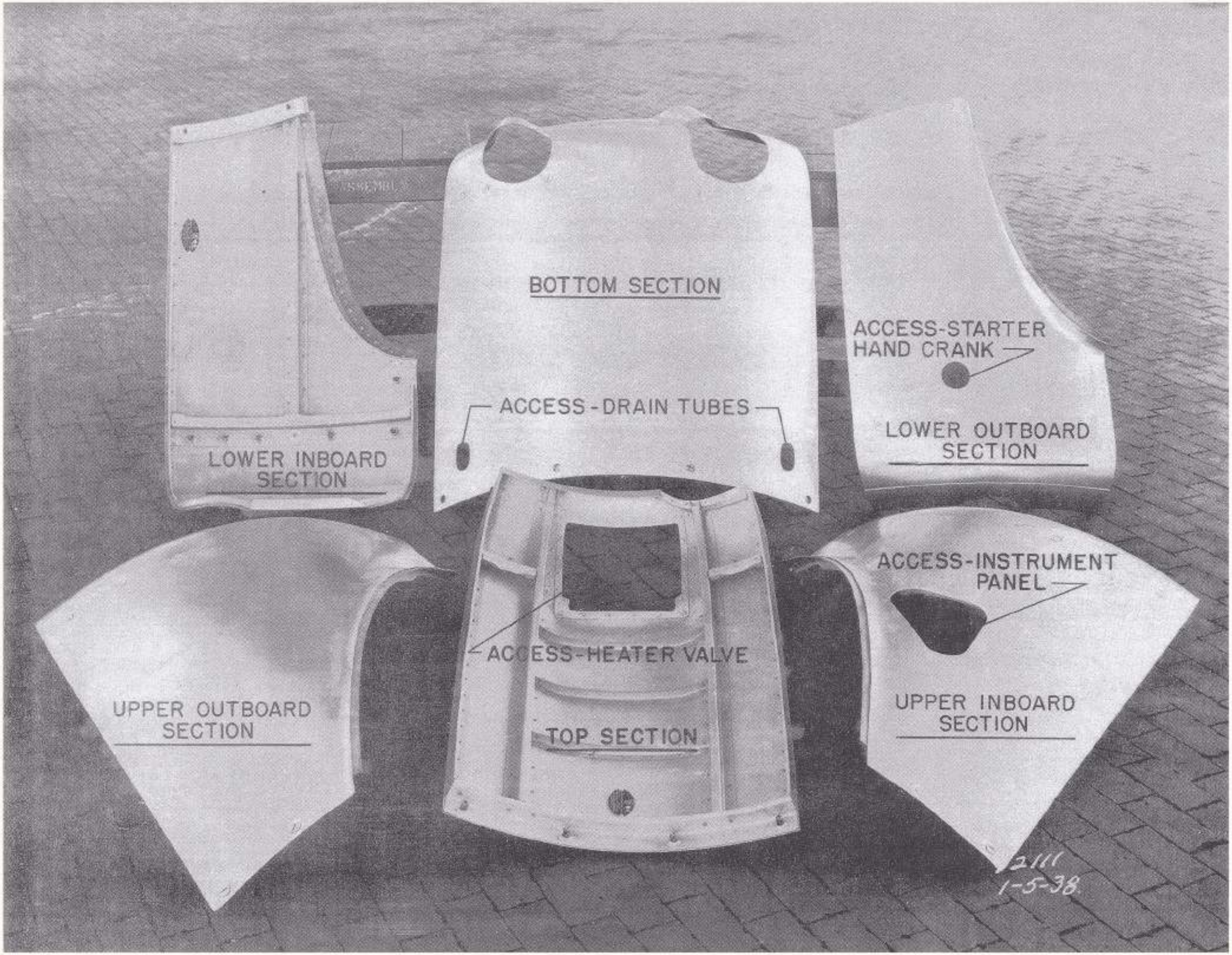
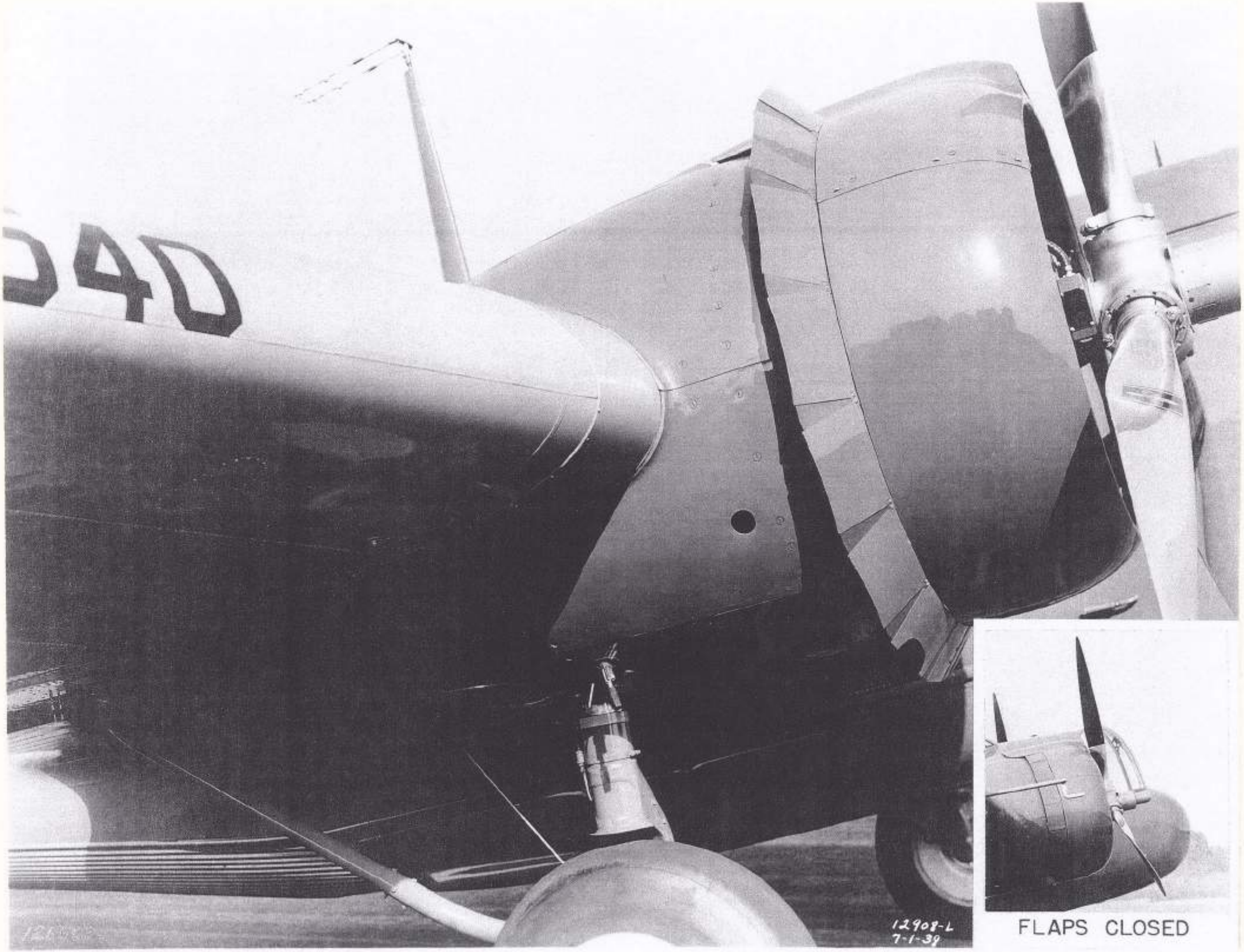


FIGURE 29 NACELLE COWL COMPONENTS - RIGHT HAND ENGINE



FLAPS CLOSED

FIGURE 29A. NACELLE COWL INSTALLATION - FLAPS OPEN

C

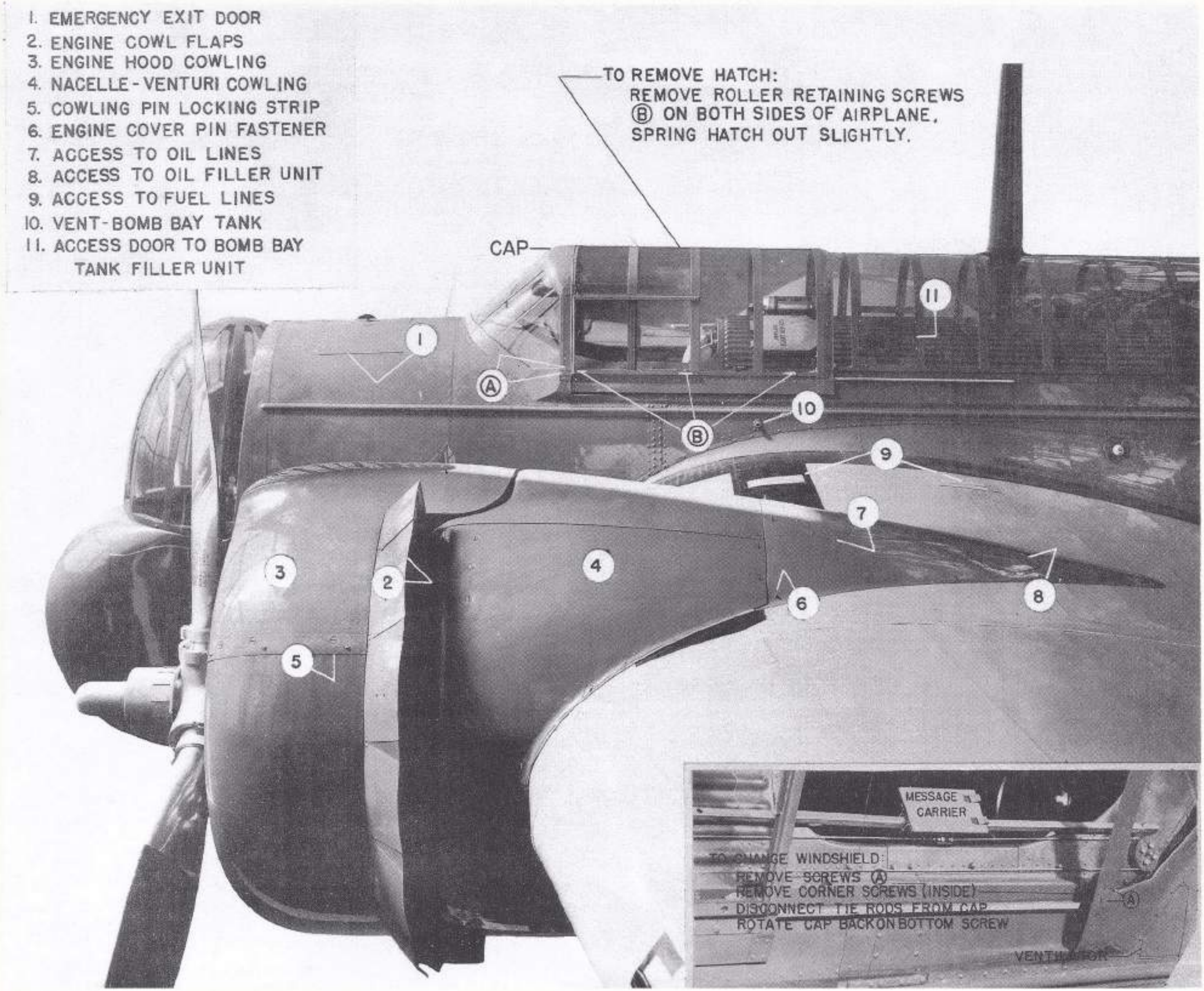


FIGURE 29-B ENGINE AND NACELLE COWLING INSTALLATION - COMPLETE

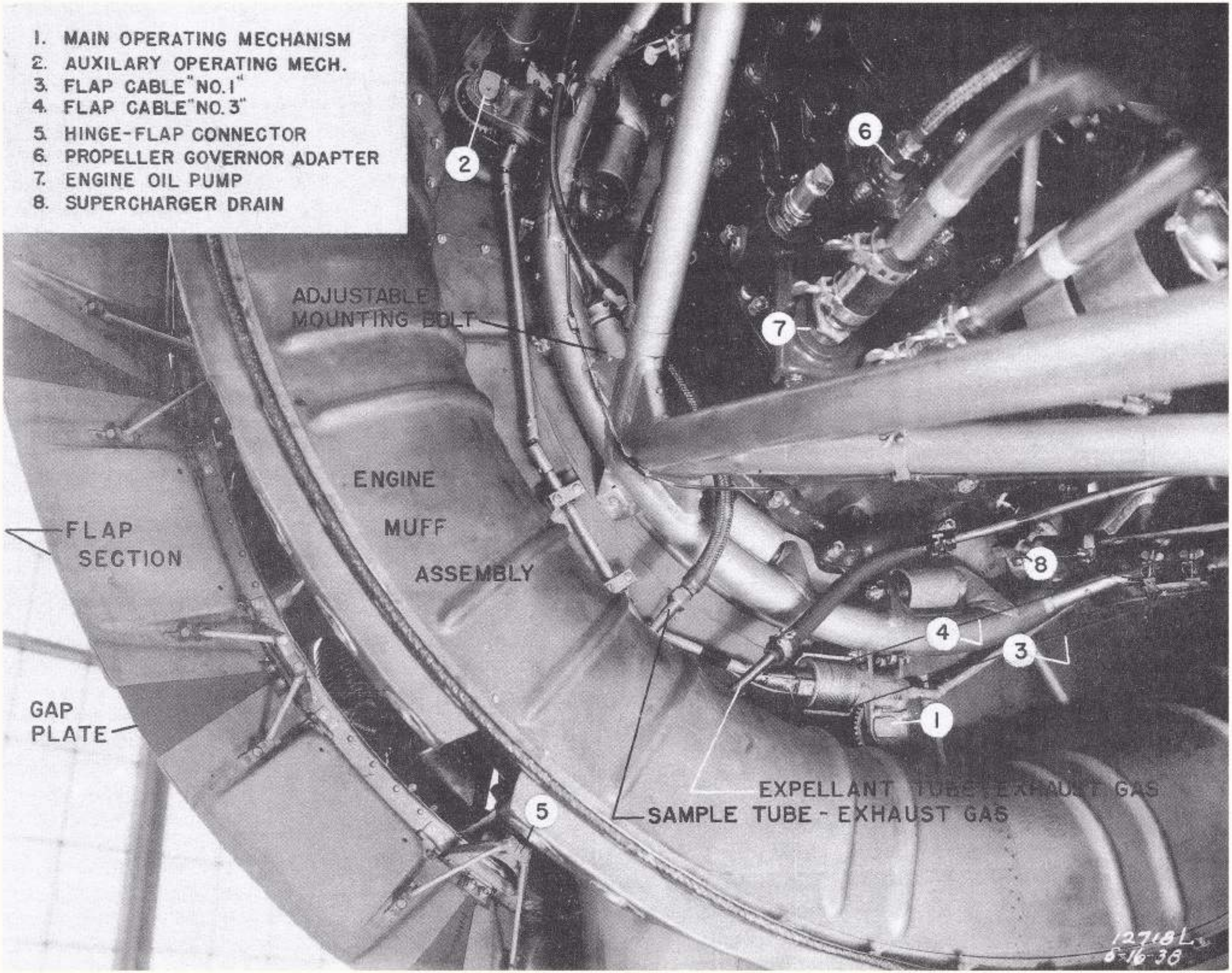


FIGURE 29-C COWL FLAP OPERATING MECHANISM - LEFT ENGINE

SECTION IX

LANDING GEAR

A. Description

The landing gear consists of the external gear together with its retracting system. The landing gear structure is of the retractable cantilever type, with a tread of 16'-0". It is equipped with 6" stroke Cleveland Pneumatic Tool Co. shock struts, hydraulic brakes, Timken roller bearings in the wheels, and streamlined tires, 45 inches in diameter.

The retracting system consists of a torque tube extending across the center section wing, just forward of the rear beam, on each end of which are aluminum alloy cable drums to which the lowering and retracting cables are attached. In the right hand side of the bomb bay this shaft is connected to a worm gear box, which may be operated manually by the pilot in an emergency or electrically for normal operation. An Eclipse electric motor located on the rear face of the rear wing beam is connected to the worm gear box through a clutch. A hand crank located in the pilot's cockpit is connected to the other side of the worm gear by means of a bevel gear and torque tube, and may be operated if so desired by the pilot. Other suitable controls are provided such as locks, switches, etc., for the proper operation of this system.

The retracting mechanism raises the wheels upward and backward into wheel wells in the wing and engine nacelles. When fully retracted all of the landing gear is concealed except a portion of the tire. The action of the gear either retracting or lowering, requires approximately 35 seconds electrically and 90 seconds manually in flight.

An indicator in the pilot's cockpit, which is mounted on the retracting hand crank bracket, indicates the approximate position of the gear at all times. In addition to this indicator a signal system is provided consisting of a rudder pedal vibrator, interlocked with the engine controls in such a way that if the throttles are closed so that the engine revolutions are less than required for minimum cruising speed, the pilot is reminded that the gear is retracted and that the locks are raised. The warning device functions unless the gear has been completely lowered and the locks dropped into position, or unless the throttles are opened sufficiently to maintain cruising speed. When the gear is in a fully extended position and locked ready to land, a white light shows on the box aft of the hand crank bracket.

Reference to Fig. 30 makes clear the general arrangement of the retracting mechanism. Operating directions are given on the indicator box to the right of the pilot's seat. Figs. 32 and 33 illustrate the landing gear structure. The master cylinder installation and brake controls are illustrated in Fig. 35 and Appendix II.

B. Electrical Operation - "To Retract"

1. Place the clutch in "Electric" position.
2. Pull the latch to "Up."

C. Electrical Operation - "To Lower"

1. Set the clutch in "Electric" position.
2. Set the latch to "Down."

Note: When the latch is operated it should be operated rapidly and moved through the complete travel. Slow or partial travel may cause arcing of the master switch and eventually malfunction of the gear. It is important that the latch mechanism be kept well lubricated with light oil to prevent rust from forming on the spring. The oil should be applied every 20 hours flying time through the latch slot in the side of the handle. Wipe excess oil off the bottom of the handle when it drains through the hole provided at the bottom.

Pulling the latch to the "Up" position operates the reversing switch through the actuating arrangement shown in Diagram "A", Fig. 30, and at the same time raises the locks, thereby engaging the master switch on the right hand lock. The locks are rigidly connected so that simultaneous operation of both wheels is assured. This master switch starts the electric motor, which retracts the gear, pushing the roller fitting on the rear landing gear strut toward the rear along the track. As the roller fittings move back, the one on the right operates the trigger on the right hand lock, as shown in Diagram "D", Fig. 30. This trigger holds the locks up as long as the gear is retracted. When the gear reaches the fully retracted position, the rear brace strut strikes the plunger shown in Diagram "C", Fig. 30, thus operating the motor cutout switch and stopping the motor. This cutout switch may be adjusted to allow for wear, and it should be adjusted by checking the gear when it is in the fully retracted position.

When the latch is moved to the "Down" position, the motor reversing switch is operated and the motor is started, allowing the gear to go down. The pin in the top of the right hand rolling block trips the trigger shown in Diagram "D", Fig. 30, which allows the locks to drop down and ride along the tops of the rolling blocks until they fall behind the latter. These lock pins are spring loaded and positively lock the gear in the down position. As the right hand lock pin drops down into the "lock" position it closes the circuit to the light at the hand control bracket, which indicates that both locks have been dropped behind the rolling blocks. Should the light not appear, the crank in the pilot's cockpit should be engaged, by depressing the thumb button and turned clockwise. A hard partial turn will obtain the lock engagement whether the light works or not.

For the wiring diagram of the landing gear system, see Figure 36.

D. Manual Operation

1. Place the clutch in the "Manual" position.
   NOTE: When the clutch is set to manual position the clutch rod actuates the motor cutoff switch, as shown in Diagram "E", Fig. 30, and at the same time disengages the motor from the worm gear unit.

2. To retract, pull the latch lever to "Up" and crank anti-clockwise.

3. To lower, set the latch to "Down" and crank clockwise.

E. Assembly

The fork-strut assembly should be bolted to the brace struts extending below the front wing spar. The rear brace strut should be bolted to the rolling block which rolls in the track at the rear spar. The retracting and lowering cables should next be attached to the half fork on the inboard side of the wheel, and to the roller fitting respectively. It should be noted that one of the rear brace strut fittings on the axle cannot be removed unless the axle is removed, therefore, if it is desired to remove this strut at any time, it should be disconnected from the forgings attached to the axle. For replacement the whole strut should be changed.

F. Maintenance

After once being set and adjusted, no further adjustment of the retracting cable system is necessary, since any slack in these cables is automatically taken up by spring action. The operation of the landing gear retracting system should be checked every 20 hours by jacking the airplane up and operating the system. When the oleos are <u>fully extended</u>, both the retracting and lowering cables should be reasonably taut for all positions of the gear, despite the variation in the amount of cable taken in or paid out by the drums. With the shock strut in the fully extended position, the distance between the centerline of hinge and centerline of axle should not be more than 3/16 of an inch over the nominal dimension of 43-5/16 inches. It may be necessary to tighten the packing gland in order to bring the strut within this dimension, particularly after the installation of new packing rings. It is very important that excessive tightening in the retracting cable be avoided. (See Par. L under WARNING).

IMPORTANT: See Special Inspection Instructions, Section XXIII.

If the landing gear fails to retract electrically, the cut-off switch located on the inboard side of the right wheel well will probably be found stuck in the "Up" position. The switch plunger must be in the "Down" position before the gear will retract electrically. The plunger should be inspected daily to see if it is in good working condition.

Fig. 30 shows the lubrication points for the landing gear structure. It is especially important that the worm gear housing be lubricated at regular intervals in accordance with instructions, using No. 4 Penola compound, manufactured by the Standard Oil Co., of New Jersey.

The Timken tapered roller bearings in the axles should be carefully checked and the adjusting nut on the axle tightened, to allow for wear in the bearings. Care should be taken that the bearings are not tightened sufficiently to bind the wheel, which should turn freely on the axle. See Par. S, Brake Adjustment.

In changing tires or wheels the airplane should be jacked up at the point indicated in Fig. 30.

G. Maintenance of Roller Fittings and Track

The trigger pin in the right hand roller fitting should be checked every 20 hours for wear. To do this, remove the track fairing and and raise the landing gear until the roller fitting is at the rear of the track. Excessive wear may be easily checked visually in this manner.

Every 40 hours both roller fittings should be carefully cleaned and inspected. This inspection is most easily done by removing the tracks. Unbolt the track from the wing, by removing the two rear bolts which are accessible by removing the screws which fasten the fairing to the wing. The four intermediate bolts are tapped into the anchor nuts and are readily removable. The forward bolts are accessible from the doors provided in the wing. If any parts are worn they should be replaced. Note: The track and roller fitting must not be greased, as the grease will catch dirt and dust and cause excessive wear. The track should be inspected every 40 hours, and kept clean.

H. Cleveland Pneumatic Tool Co. Shock Struts

An instruction plate is attached to the landing gear half fork struts for the strut, Cleveland Part No. A-7562. These struts are combined hydraulic and pneumatic type. Impact loads are dissipated largely through hydraulic means, by forcing fluid through an orifice. Taxiing loads are absorbed mainly by the compression of the air. When load comes on the strut, the fluid is forced through the orifice in the piston, past the metering pin, into the upper chamber where the rising fluid level compresses the air above it. When the strut has made a sufficient stroke to absorb the energy of the impact, the air in the tube which has been compressed, expands and forces the oil back, extending the strut.

NOTES ON INSTALLATION OF NEW SHOCK STRUT

The shock strut is attached to the half-fork, part D-124507 by means of two AN-6 bolts as shown in view B-B on G.L.M. Drawing P-124049 and 50. It is extremely important that the shock strut be fitted tightly against the 3/32 inch shoulder at the top of the half-fork before finish reaming the holes for these bolts. Special attention must also be paid to alignment as noted in the following paragraph.

Six AN-7 bolts are used to attach the shock strut to the upper hinge fitting, part C-124506. The holes for these bolts must be drilled with the strut in the fully extended position and with the hinge centerline and the axle centerline parallel to each other, as shown and noted on P-124049 and 50. Full extension is necessary to insure the engagement of the lugs of the internal torque device. The fully extended length of the strut is 27-7/32" ± 3/32. If the strut appears short it is because these lugs are not engaged and it is necessary to rotate the cylinder around the piston until they do engage. This engagement then definitely fixes the cylinder in relation to the piston in the extended position only and should occur within 7/16 inches of the full extended length. This device is installed for the one purpose of preventing rotation of the wheel about the centerline of the oleo strut while the wheel is in its retracted position.

I. Filling the Shock Struts

WARNING: Release air in strut before disassembling.

The fluid used in this strut is a mixture of butyl alcohol and castor oil, U.S. Army Specs. Nos. 4-503-85 and 2-8B respectively. For winter operation use equal parts; for summer operation, three parts castor oil and one part butyl alcohol. Standard Lockheed fluid, obtainable at any hydraulic brake service station, may be used for refilling in case of emergency.

These struts are correctly filled when the fluid comes to the level of the filler plug with the strut fully compressed, and with the airplane in the three point landing position. Leakage of oil to a level $\frac{1}{2}$ inch below this point will not materially affect the characteristics of these struts. To check the fluid level, the air must be let out.

J. Inflation of the Shock Struts

Air pressure around 400 pounds per square inch is required to inflate these struts when the airplane is fully loaded. The hand pump is capable of boosting the pressure to 1,000 pounds per square inch when attached to a hangar high pressure air line of 80 to 100 pounds per square inch. If this pressure of 400 pounds per square inch cannot be obtained with this booster pump there is probably a leak somewhere in the air line from the hangar, or in the pump valves or connections.

Air should be added to the landing gear strut until the distance between the bottom of the yoke at the top end of the strut and the top of the cylinder (not the gland nut) is 3-3/8 inches, especially when the ship is overloaded.

For full inflation the distance should be approximately $\frac{1}{4}$ of an inch greater, as moving the airplane around will cause some absorption of the air by the fluid. A variation of $\frac{1}{4}$ of an inch either way for the final reading should not be considered of importance. The inflation should be made with the airplane out of the wind and without the engines running, and it should be checked with the airplane moving forward and the tail on the ground.

After the struts are once correctly adjusted, readjustment should not be made for minor changes, as this may be due to changes in the position of the airplane, changes of load, wind action, packing friction, rolling the airplane backward, etc. Check only after the airplane has been loaded, as it is to be flown, and has been rolled forward with the tail wheel down. Do not over inflate, as hard taxiing and bouncing at contact with the ground will result.

K. Air Valves on the Shock Struts

The air valve is a special Schrader rubber type, developed for this purpose. This valve functions like the one in an automobile tire. The hex cap provided with this type of valve has a soft metal seat to furnish a secondary seal. It should be screwed down tightly. The cores are replaceable.

The valve core and the seat around the filler plug should be tested for leaks. Mineral oil should not be allowed to reach the packing rings, as gumming may result.

L. Adjustment of Lock Mechanism

The landing gear master switch is located above, and is directly connected to the R.H. lock, and as soon as this lock is raised 1/16 of an inch above its roller fitting, the motor is started and the gear retracted. The right and left hand locks are actuated by a single "push-pull" tube, rigidly connected to each lock through a system of levers. The "push-pull" tube is actuated by a lever connected at the right side of the fuselage and operated by the pilot through a cable-tube system. Operation by the pilot pushes the "push-pull" tube to the right, the right side being in compression and the left side in tension; each load being applied by the springs in the right and left locks, respectively. Both springs load the "push-pull" tube in the same direction, and opposite to the load applied by the pilot.

On assembly of the connecting tube to the right and left hand lock pins, care must be taken to see that static balance is obtained. This is assured if both lock pins are fully out.

If the left hand lock pin is slightly retracted the cross tube is in tension and the system is not statically balanced.

If the right hand lock pin is slightly retracted the cross tube is in compression and the system is unbalanced. This condition is serious because the left hand lock will still be closed after the motor has started. The motor will then stall, and the result will probably be a burned out "overload clutch."

When once assembled and operated, the linkage needs no further adjustment.

W A R N I N G

There are two slack takeup systems in the retracting gear cables, one for the retracting cable and one for the lowering cable. The one on the retracting cable is to allow for oleo action, and it holds the cable under slight tension when the oleos are half compressed under static load. The slack takeup spring is extended when the airplane is in the air, due to the fact that the oleo lengthens, and therefore, the length of this cable must increase. As this cable is connected to the drum mounted on the torque shaft, which in turn is connected to the irreversible worm gear unit in the right rear side of the bomb bay, the only way this cable can increase its length is by the movement of the slack takeup device.

If the airplane is resting on its wheels and the hand crank in the pilot's cockpit is moved to retract the gear before the lockpins are raised, the slack takeup spring will be extended until it reaches the end of its travel. After the airplane has taken off and the oleos extend under their high air pressure, a very high tension load will be put into this cable, which may damage the wing structure or the retracting system. CAUTION: In view of the above it is, therefore, very important that the hand crank never be operated when the airplane is resting on its wheels. See the warning sign on the right longeron above the crank.

As a safety measure the hand crank should be engaged before take-off and turned in a clockwise direction until the crank comes to a dead stop. This will put all of the slack in the system into the retracting cable, thereby allowing for oleo extension in the air.

M. Removal of Worm Gear Box.

1. Remove the lower left hand fuselage to wing fillet at the rear fuel tank door.

2. Remove both rear fuel tank doors.

3. Remove the three 5/16" Dia. bolts from the outboard splice in the left and right hand shafts (F-124287). This splice is adjacent to the second corrugation brace from the fuselage. Before removing the bolts in the shaft, disconnect the retracting cable to remove any strain from the shaft.

4. Disconnect the left and right shaft from the worm gear by removing three 5/16" dia. bolts from each side. These bolts are shown in Fig. 38.

5. Slide both shafts outboard about 5 inches by telescoping the small splice shaft into the large shaft outboard from the disconnected splice.

   CAUTION: To avoid galling the two shafts together when telescoping, the small shaft must be smoothed down and liberally coated with grease.

6. Disconnect the fore and aft torque shaft from the cockpit indicator assembly and the worm gear after first removing the small guard at the indicator assembly.

7. Slide the shaft forward over the indicator assembly sufficiently far to clear the worm gear.

8. Disconnect the tubular brace (A-105907) from the worm gear. This brace is shown in Fig. 38

9. Slide the worm gear case inboard, out of the right hand cross shaft, and remove. CAUTION: When reassembling, be sure that the hand crank indicator in the cockpit is set to read "Down" when the gear is locked in the down position. Otherwise the system will be thrown out of adjustment.

N. To Remove a Lowering Drum

1. Disconnect the cable from the drum (C-124285 L. H. or C-124284 R. H.)

2. Disconnect the outboard tubular brace (A-124291) at the bottom and swing it outboard.

3. Completely remove the outboard drum support (C-103947).

4. Mark the shaft in line with the letter "A" stamped on the drum.

5. Remove the bolts attaching the drum to the shaft and slide the drum outboard and off.

O. To Remove a Retracting Drum

1. Disconnect the cable from the retracting drum (B-103989). Also disconnect the cable from the adjacent lowering drum.

2. Disconnect the tubular pulley bracket braces (A-124291 and A-124292) at the bottom and swing them outboard and inboard respectively.

3. Remove the bolts attaching the drum to the shaft. Also remove the bolts from the torque shaft splice just inboard from the drum.

4. Remove the short torque shaft assembly (A-124289) and the shaft supports (C-103948 and C-103947) after first removing the bolts attaching the shaft supports to the rear spar. Do not allow the retracting gear to rotate on the shaft while doing this.

5. Mark the shaft in line with the letter "A" stamped on the drum.

NOTE: When reinstalling the drums, attach the lowering cable before the retracting cable is attached.

6. Replacement drums must be ordered in matched pairs. To match the drums, wrap the cables on them in accordance with the instructions given on drawings B-103989, C-124284, and C-124285. The difference in length between the lowering and retracting cables should be .481" plus-minus 1/8". If the drums do not match according to this figure, the system may be thrown out of "time" and undue tightening of the cables will result.

P. (a) To Replace a Retracting Cable

1. Jack up the ship at the wing jack pads or lift ship off the ground by means of the hoist cable. The landing gear must be in the full "Down" position.

2. Remove old cable from drum.

3. Remove bolts from both large pulleys located near the bottom skin of the wing. This pulley is shown in Fig. 37. Also remove the bolt from the slack take-up pulley.

4. Feed the drum end of the new cable up through the slot in the wing

skin, over the large pulley and over the slack take-up pulley, then under the other large pulley and over and around the retracting drum $2\frac{1}{2}$ turns. (See Drawing B-103989.) Start the cable in the 6th groove from the large end of the drum. The cable bushing should line up with the bolt hole on the rear side of the drum. Insert the bolt.

NOTE: Make sure that the cable lies snugly in the bottom of the drum grooves. If necessary use a wooden block to seat the cable.

5. Replace the bolts in the large pulley and the slack take-up pulley.

6. Disconnect the rear brace strut at the roller fitting.

7. Push the landing gear back far enough to permit connecting the adjustable end of the retracting cable to the eye bolt in the half fork.

8. Pull the gear forward and reconnect the rear brace strut.

9. Adjust cable until taut. (Repeat operation 6, 7, and 8 if necessary.)

10. Check the operation of the retracting system with the manual control.

11. Lower the ship to the ground.

P. (b) To Replace a Lowering Cable

1. Jack up the ship at the wing jack pads or lift the ship off the ground by means of the hoist cable. The landing gear must be in the full "Down" position.

2. Remove old cable, including the clevis at the roller fitting.

3. Disconnect rear brace strut at roller fitting.

4. Remove the guard from the large pulley in the wing skin. This guard is shown in Fig. 37.

5. Remove the small idler pulley and the slack take-up pulley, both of which are shown in Fig. 37.

6. Detach both retracting cables from the landing gear half-fork and fasten weights (at least 10 pounds) to the free ends.

7. Crank landing gear by hand to full "Up" position. CAUTION: Watch the indicator carefully while doing this to prevent damaging it by forcing it against the rear stop.

8. Place drum end of new cable on the drum with the cable bushing lined up with the bolt hole on the bottom of the drum shaft. Attach the cable and wrap it around the drum 1-3/4 turns. The cable should leave the drum from the first complete groove on the small end. (See Drawings C-124284 and C-124285.)

9. Assemble the jam nut to the new clevis and attach the clevis to the roller fitting.

10. Replace the small idler pulley and slack take up pulley. The cable must pass under the idler pulley and over the take-up pulley.

11. Hold the cable tight by pulling on the loop formed by the slack length and slowly crank the gear to the full "Down" position. Allow the cable to be drawn up into the slot in the roller fitting.

    Note: Be sure to pull the cable down to the bottom of the drum grooves. Use a wooden block if necessary.

12. Connect the retracting cables to the half forks and attach the rear brace strut to the roller fitting.

13. Adjust the cable, by means of the clevis at the roller fitting, until it is taut with the slack take-up spring extended full length. Lock the clevis with the elastic stop nut that was removed from the old clevis.

14. Check the operation of the gear with the manual control and lower the ship to the ground.

Q. Maintenance and Adjustment of Hydraulic Brakes

The operating principle of the hydraulic brakes installed on this airplane is the same as that of the mechanical type, except that a hydraulic means of application is used instead of the conventional mechanical means and therefore, the two brakes are treated separately, so far as adjustment and maintenance is concerned.

Each brake is equipped with a hydraulic cylinder with a piston and suitable connections, so that when fluid is admitted to the cylinder under pressure, the force on the piston is transmitted to the primary brake shoe, thus effecting brake application.

Hydraulic pressure is obtained by operation of the master cylinder located in the pilot's cockpit beside the rudder pedals.

The tubing used throughout the system is aluminum alloy 5/16" x .042. The tube fittings are the Parker triple compression type, which utilize a sleeve under the tube nut, and care should be taken that these fittings are tight at all times in order to prevent leaks.

Little trouble with this hydraulic brake installation will be experienced if the following precautions are taken:

1. Use only brake fluid consisting of 90% Butyl alcohol and 10% castor oil during cold weather (or when the ground air temperature is below 30°F). Use only a fluid consisting of 60% Butyl alcohol and 40% castor oil during warm weather (or when the ground air temperature is above 30°F.) Any other fluid may congeal, corrode metal parts, or cause deterioration of rubber parts.

2. When the pedal action becomes spongy or other indications of entrapped air are noted, bleed the line. Air is compressible and should be removed from any hydraulic brake system.

3. Keep the level of the fluid in the reservoir chamber at the level of the upper indicating screw at all times.

4. See that the bleeder valve is closed tightly and that the dust cap is properly installed on this fitting.

5. Inspect the hydraulic lines, and all fittings for leaks every 20 hours. If leaks are found, repairs should be made at once. If any lines require replacement, the ends of the tubing should be flared, using the proper flaring tool.

R. Operating and Maintenance Instructions--Brake Cylinders

For complete instructions, see Warner Aircraft Corporation Instruction List included with the Miscellaneous Bulletins. See Appendix II.

S. Brake Adjustment

Bleeding the hydraulic system is not necessary before each brake adjustment, unless there is indication of air in the system.

1. Before attempting to adjust the brakes the wheel should be removed and the brake inspected for damaged parts, and the brake lining for grease. If the lining is greasy replace with new lining. If the brake return springs do not have a good initial tension they should be replaced.

2. Inspect the wheel bearings and remove any thin grease. Repack the bearings, using a small quantity of Grease, Lubricating, Cup, Medium, Spec. 2-29, and renew the felt washer if necessary.

3. Replace the wheel and the wheel bearing adjusting nut. Be sure there is no brake drag. Then, with the wheel spinning, tighten the adjusting nut slowly until a bearing drag on the spinning wheel is noticed. Back off the nut approximately $\frac{1}{4}$ turn and lock in position with the cotter pin. Brake drag should not be confused with bearing tightness while rotating the wheel during the bearing adjustment. The brake should now be adjusted as follows: See Fig. 34.

Loosen the eccentric lock nut and turn the eccentric in the direction of wheel rotation, until the wheel is locked in position. Back off the eccentric until the wheel just rotates freely. With a close fitting wrench hold the eccentric in this position and tighten the lock nut. This should provide a clearance of .010 inch or less at the feeler gauge slot 0-1, which should be checked.

Uncover the star wheel adjusting screw hole by rotating the cover plate, and with a screw driver turn the star wheel away from the axle until a brake drag is noticed when turning the wheel by hand. Back off the star wheel until there is no brake drag. Replace the cover plate. This should give a brake shoe clearance at the feeler gauge slot 0-2 of not less than .010 inch, which should be checked.

T. Tire Pressures

Tires Bearing Deflection Markers - To determine proper inflation pressures, tires will be inflated to the point that with normal airplane loading the deflection marks will just touch the ground. When using these markers, the tires should be resting on a smooth firm surface.

U. Maintenance of Electrical Retracting System

a. Master Switch - This switch is the major control switch of the system. It contains also an indicator light switch for the light at the hand crank bracket. In addition the master switch terminates the downward travel of the landing gear. It is located on the rear face of the rear spar, above the right hand landing gear lock pin in the center wing.

In case of failure of the master control switch, investigate the switch for short circuits, poor connections, dirty contacts or poor contact, indicated by arcing and burned points. If the fault seems to be in the contact between the spring "Fingers" and the buss plate, remove the switch from the airplane. To accomplish this it is necessary to detach the mechanical and electrical connections and the conduit from the box and the switch. By working through the upper door at the rear spar and through the space provided by the landing gear wheel well, the box may be unbolted and removed. Remove the sliding portion. The free position of the contact "Fingers" should be 1/16" below the slide surface. This amount of displacement should give a contact load of 3 lbs, which is ample if the surfaces are clean and true. If these conditions are not met the parts should be renewed. The load can be easily checked by means of a spring scale and a buzzer hookup.

Care should be taken not to strain the switch in making this check.

The indicator light contacts in this switch should have a free position 1/32" maximum, below their contact points on the sliding portion.

In replacing the switch or renewing it, be very careful to align it properly, so that all elements work freely and without distortion. The proper functioning of the lock mechanism depends on freedom from excess friction.

With the lock pin in the full down position the switch actuating turnbuckle eye must be 5/16" below the fulcrum of the actuating lever.

b. Reversing Switch - The function of this switch is merely to reverse the field current through the motor. It depends for its power supply on the master switch. It is located in the bomb bay on the R.H. side, and is actuated by the rod between the control handle and the lock cables.

In case of failure check for loose connections, dirt, and arcing. The contact gap should be .046", and engagement should be $\frac{1}{4}$" to 3/8" in either direction. In replacing the switch, be careful to obtain this dimension.

c. Motor Cutout Switch - This switch is used to open the electric circuit during manual operation, and as an added safety feature in case of a failure in the electric system. It is located in the bomb bay on the R.H. side, and is actuated by the rod between the clutch handle in the cockpit and the clutch aft of the worm gear.

In case of failure check for dirt, short circuits, and loose connections. Also check toggle for wear and for excessive friction in guides or on box cover seal. Check micarta arc snuffers for interference. If switch is worn excessively it should be replaced. In mounting a new switch be careful to secure it rigidly to the structure without distorting the box; and check the toggle action so that it is fast and free. Adjust the clutch rod so that the toggle handle can snap all the way in either direction.

d. Up Position (Stop) Switch - This switch breaks the electric circuit at the upward end of the landing gear travel. It also acts as a junction box for wires from the right engine nacelle to the master switch and the reversing switch. It is located in the wing on the inboard side of the R. H. landing gear wheel well.

This switch is the same type as the Motor Cutout Switch (See "c" above).

In case of failure check as in "c." In mounting a new switch be careful to secure rigidly to the structure without distorting the box, so that the toggle will snap fast and free. The actuating rod should be adjusted as shown on drawing R-124047, and it should never be screwed out so far that the threads disappear in the top of the nut. This adjustment is provided to make the switch cutout before the steel stop is hit by the rear landing gear brace strut.

e. Throttle Switches - These switches complete the vibrator circuit, if the throttles are closed beyond the position necessary to maintain minimum cruising speed before the lock pins are down. They are located below the throttle rods where the latter run above the center wing inside the fuselage.

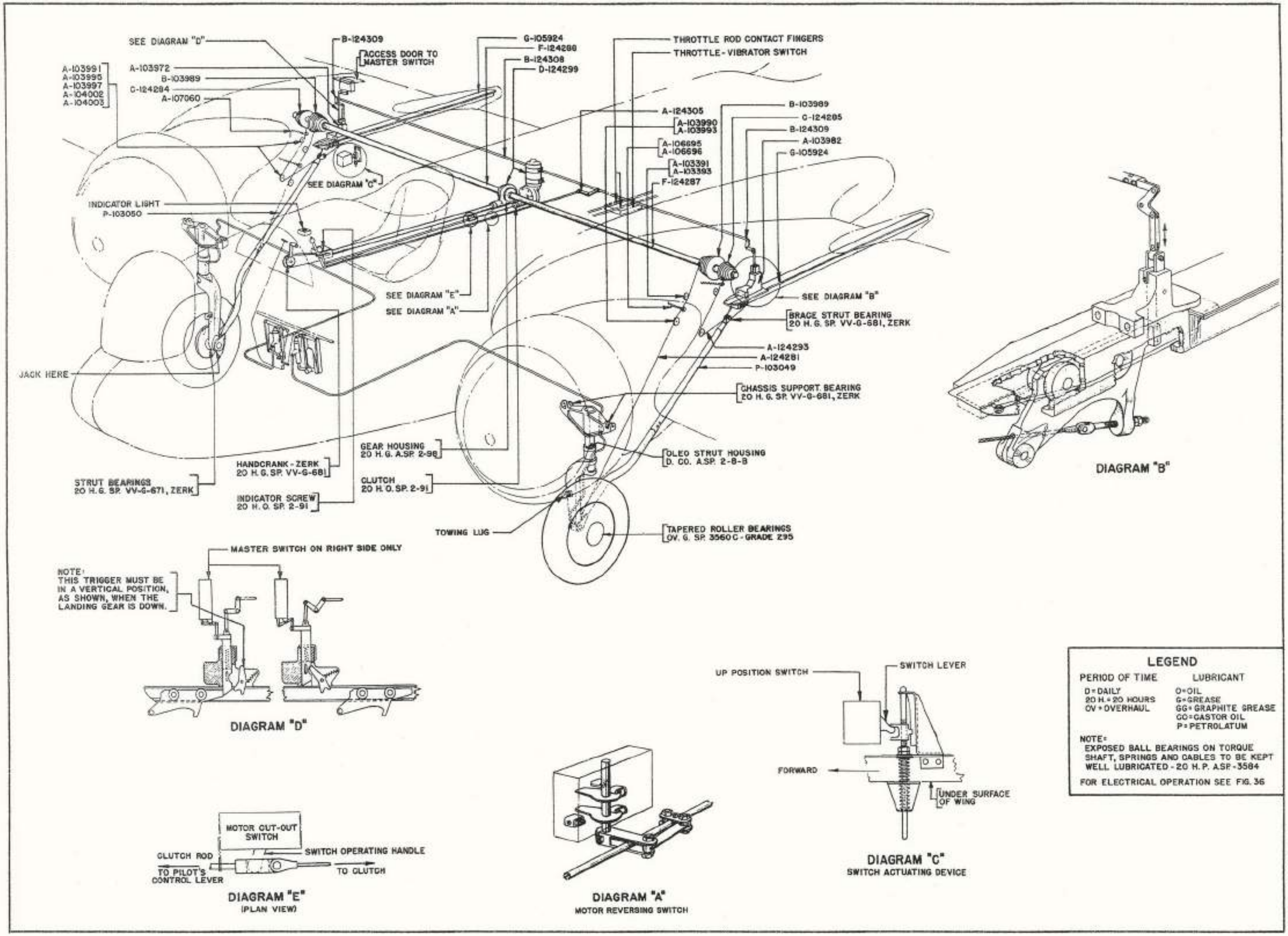
Adjustment of switch contact to engine is accomplished by moving the throttle rod pressure fingers fore or aft along the rods as required.

f. Engine Ignition Switch - The master ignition switch also controls the indicator light circuit, and these lights will not function if this switch is "Off." It is located in the lower L. H. corner of the pilot's instrument board.

CHART - TROUBLE SHOOTING

ELECTRIC RETRACTING SYSTEM

Symptoms	References are to Part U of this section.
1. Gear fails to go up when control is pulled back to "Up" position.	1. Clutch handle must be in forward "Electric" position. (See "c"). 2. "Up Position" switch at right wheel well. (See "d"). 3. Master Switch. (See "a"). 4. Reversing Switch. (See "b"). 5. Wiring (See Fig. 36).
2. Gear fails to go down when control handle is pushed forward to "Down" position.	1. Clutch handle must be in forward "Electric" position. (See "c"). 2. R. H. lock must be held open by trigger arrangement of casting. (See Fig. 30). 3. Reversing Switch. (See "b"). 4. Master Switch. (See "a"). 5. Wiring (See Fig. 36).
3. Light does not light when lock pins are down.	1. Ignition switch (See "f"). 2. Bulbs and sockets. 3. Switch at rear spar above R. H. landing gear lock pin. (See "a" and "b"). 4. Wiring (See Fig. 36).
4. Vibrator does not function when throttles are closed and lock pins are raised.	1. Throttle Switches (See "e"). 2. Master Switch (See "a"). 3. Check functioning of vibrator with independent source of current. 4. Wiring (See Fig. 36).
5. Gear fails to go far enough for lock pins to fall.	1. Contact on master switch at end of stroke. (See "a"). 2. Adjustment of linkage at master switch. 3. Dirt and grease in track and at stop block, causing motor to stall and not permitting trolley to reach stop block. (Clutch in motor will slip when motor is overloaded- 55 Ft. Lb. Torque.)
6. Landing Gear fails to operate smoothly.	1. Possibility of wear in the retracting mechanism which should be inspected per Special Instructions,


SEE DIAGRAM "D"
B-124309
ACCESS DOOR TO MASTER SWITCH
G-105924
F-124286
B-124308
D-124299
THROTTLE ROD CONTACT FINGERS
THROTTLE-VIBRATOR SWITCH
A-103991
A-103995
A-103997
A-104002
A-104003
A-103972
B-103989
C-124284
A-107060
SEE DIAGRAM "C"
A-124305
A-103990
A-103993
A-106695
A-106696
A-103391
A-103393
F-124287
B-103989
C-124285
B-124309
A-103982
G-105924
INDICATOR LIGHT
P-103050
SEE DIAGRAM "E"
SEE DIAGRAM "A"
SEE DIAGRAM "B"
BRACE STRUT BEARING
20 H. G. SP. VV-G-681, ZERK
A-124293
A-124281
P-103049
CHASSIS SUPPORT BEARING
20 H. G. SP. VV-G-681, ZERK
JACK HERE
GEAR HOUSING
20 H. G. A.SP. 2-98
HANDCRANK - ZERK
20 H. G. SP. VV-G-68
OLEO STRUT HOUSING
D. CO. A.SP. 2-8-8
STRUT BEARINGS
20 H. G. SP. VV-G-671, ZERK
CLUTCH
20 H. O. SP. 2-91
INDICATOR SCREW
20 H. O. SP. 2-91
TOWING LUG
TAPERED ROLLER BEARINGS
OV. G. SP. 3560C - GRADE Z95
DIAGRAM "B"
MASTER SWITCH ON RIGHT SIDE ONLY
NOTE:
THIS TRIGGER MUST BE IN A VERTICAL POSITION, AS SHOWN, WHEN THE LANDING GEAR IS DOWN.
DIAGRAM "D"
UP POSITION SWITCH
SWITCH LEVER
FORWARD
UNDER SURFACE OF WING
DIAGRAM "C"
SWITCH ACTUATING DEVICE
MOTOR CUT-OUT SWITCH
CLUTCH ROD
SWITCH OPERATING HANDLE
TO PILOT'S CONTROL LEVER
TO CLUTCH
DIAGRAM "E"
(PLAN VIEW)
DIAGRAM "A"
MOTOR REVERSING SWITCH
LEGEND
PERIOD OF TIME
D = DAILY
20 H. = 20 HOURS
OV = OVERHAUL
LUBRICANT
O = OIL
G = GREASE
GG = GRAPHITE GREASE
CO = CASTOR OIL
P = PETROLATUM
NOTE:
EXPOSED BALL BEARINGS ON TORQUE SHAFT, SPRINGS AND CABLES TO BE KEPT WELL LUBRICATED - 20 H. P. A.SP. - 3584
FOR ELECTRICAL OPERATION SEE FIG. 36

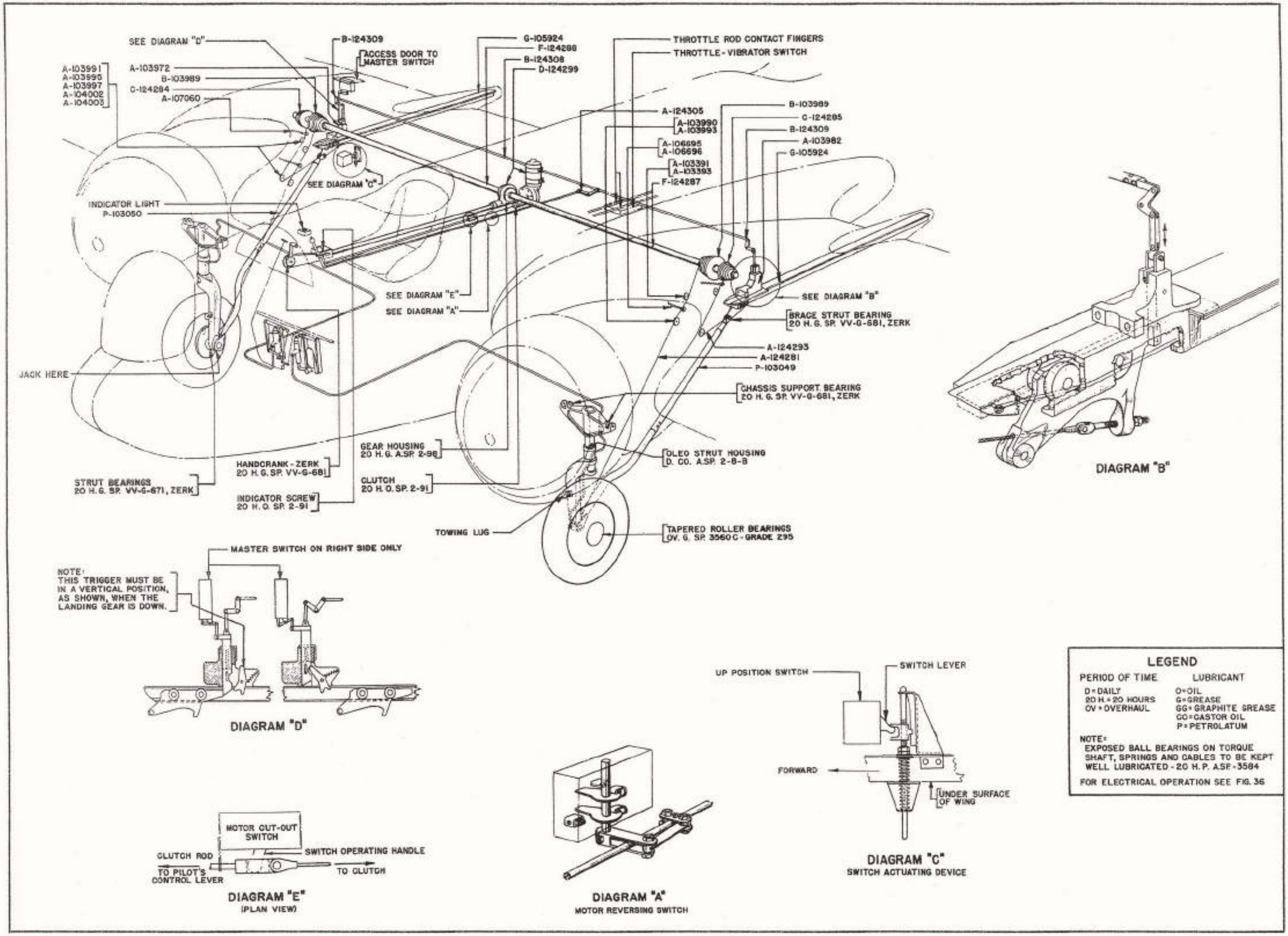


FIGURE 30 LANDING GEAR DIAGRAM

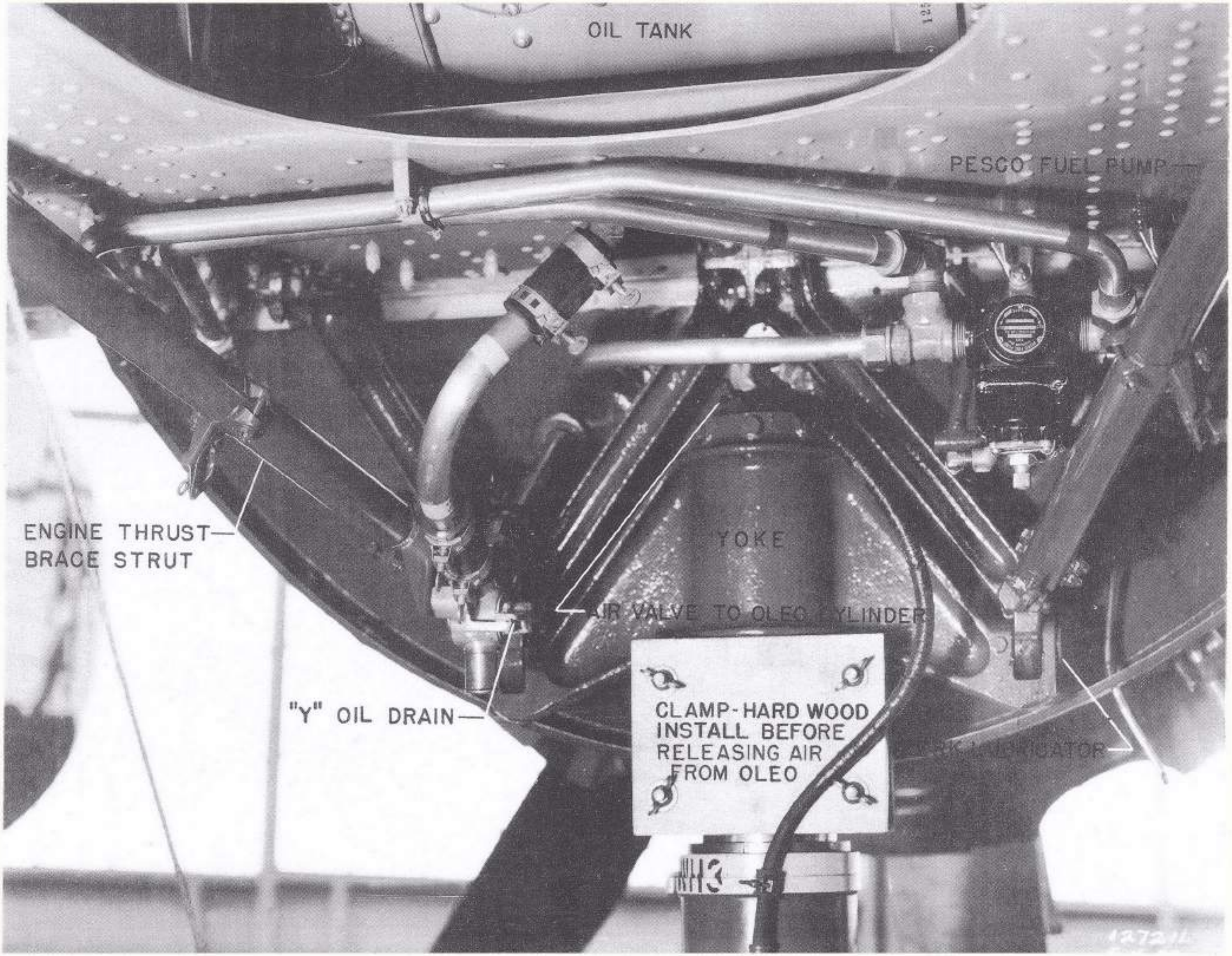


FIGURE 32 LANDING GEAR SUPPORTING STRUCTURE

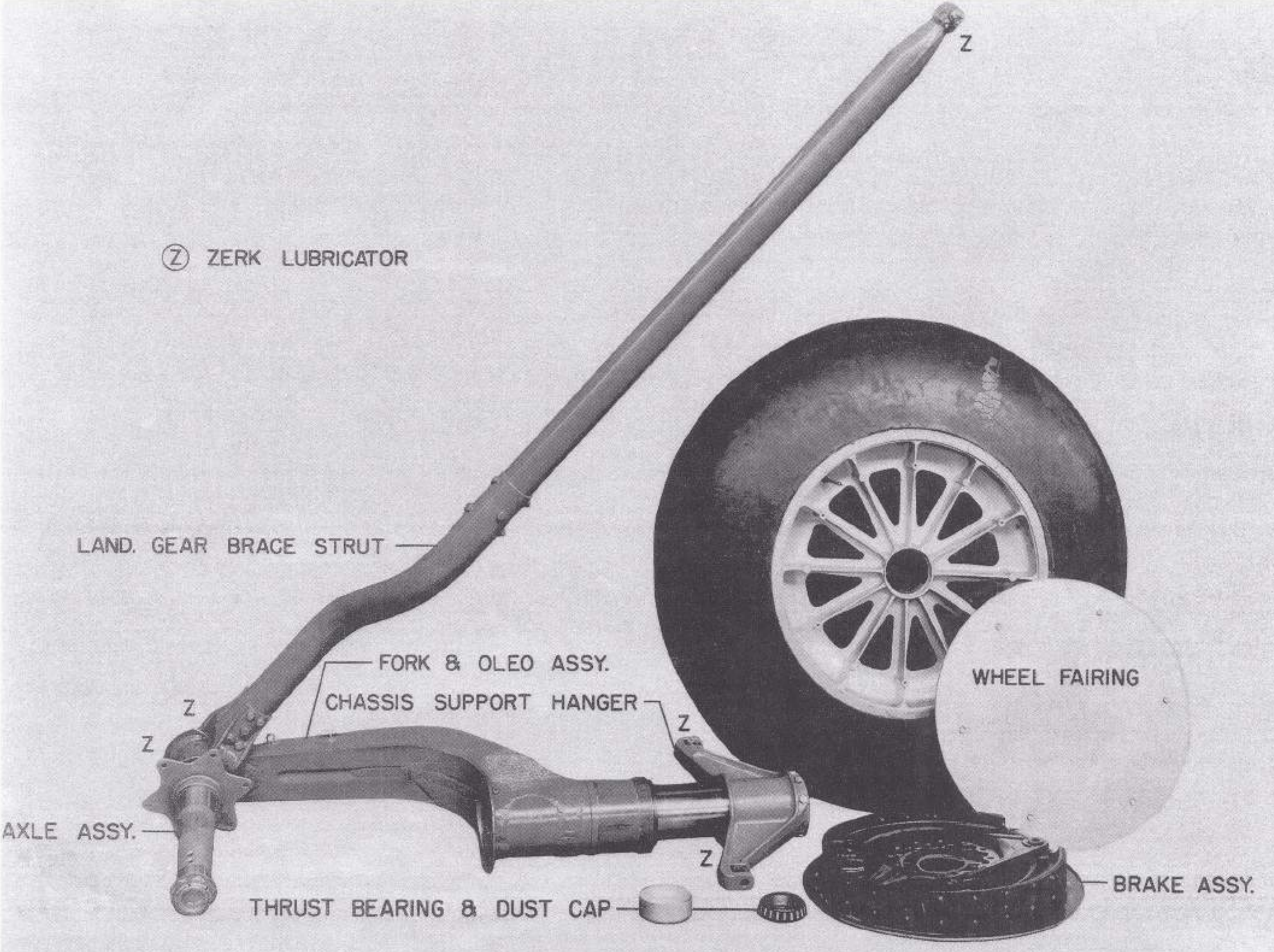


FIGURE 33 LANDING GEAR ASSEMBLY

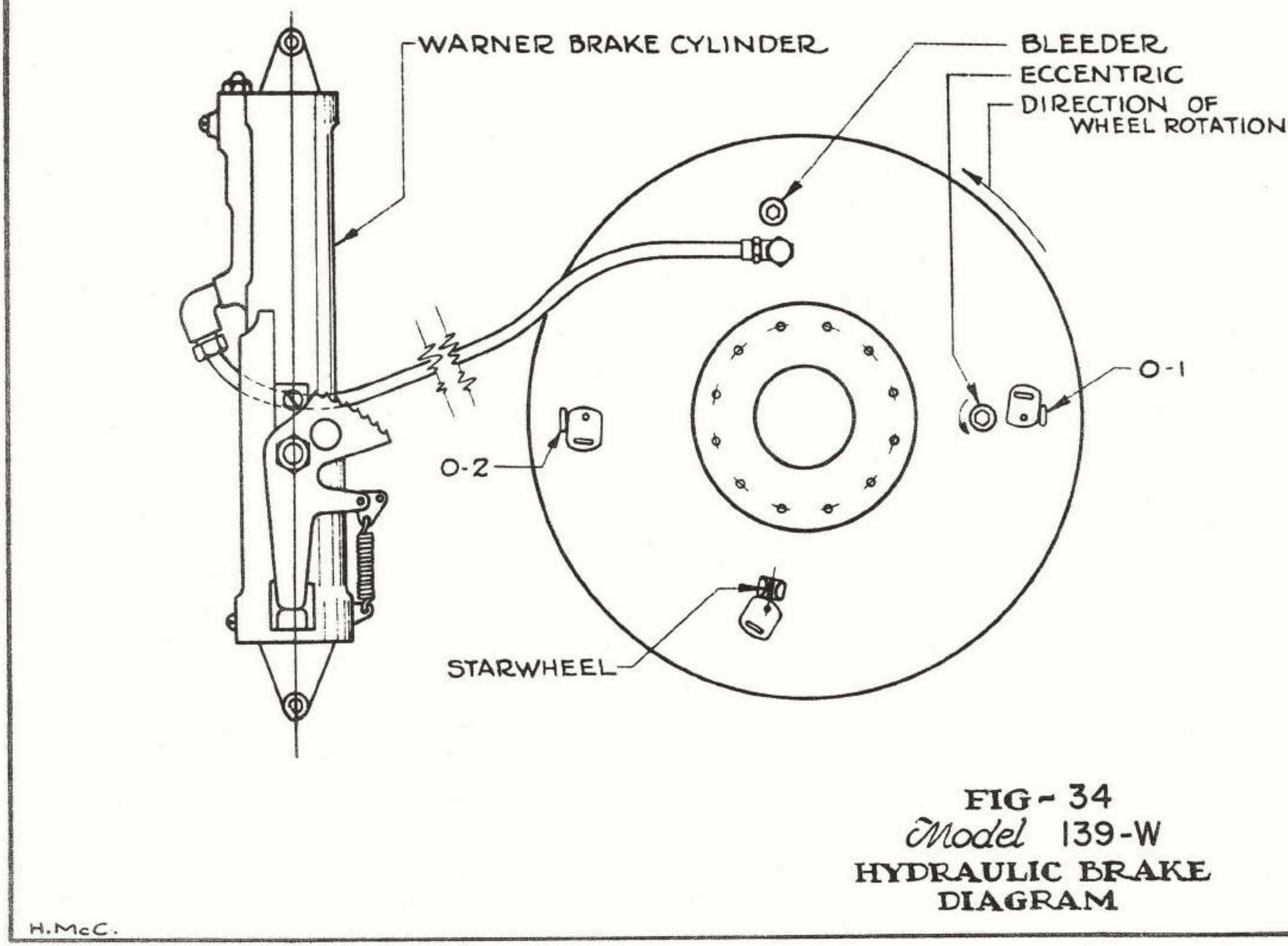


FIG - 34
Model 139-W
HYDRAULIC BRAKE DIAGRAM

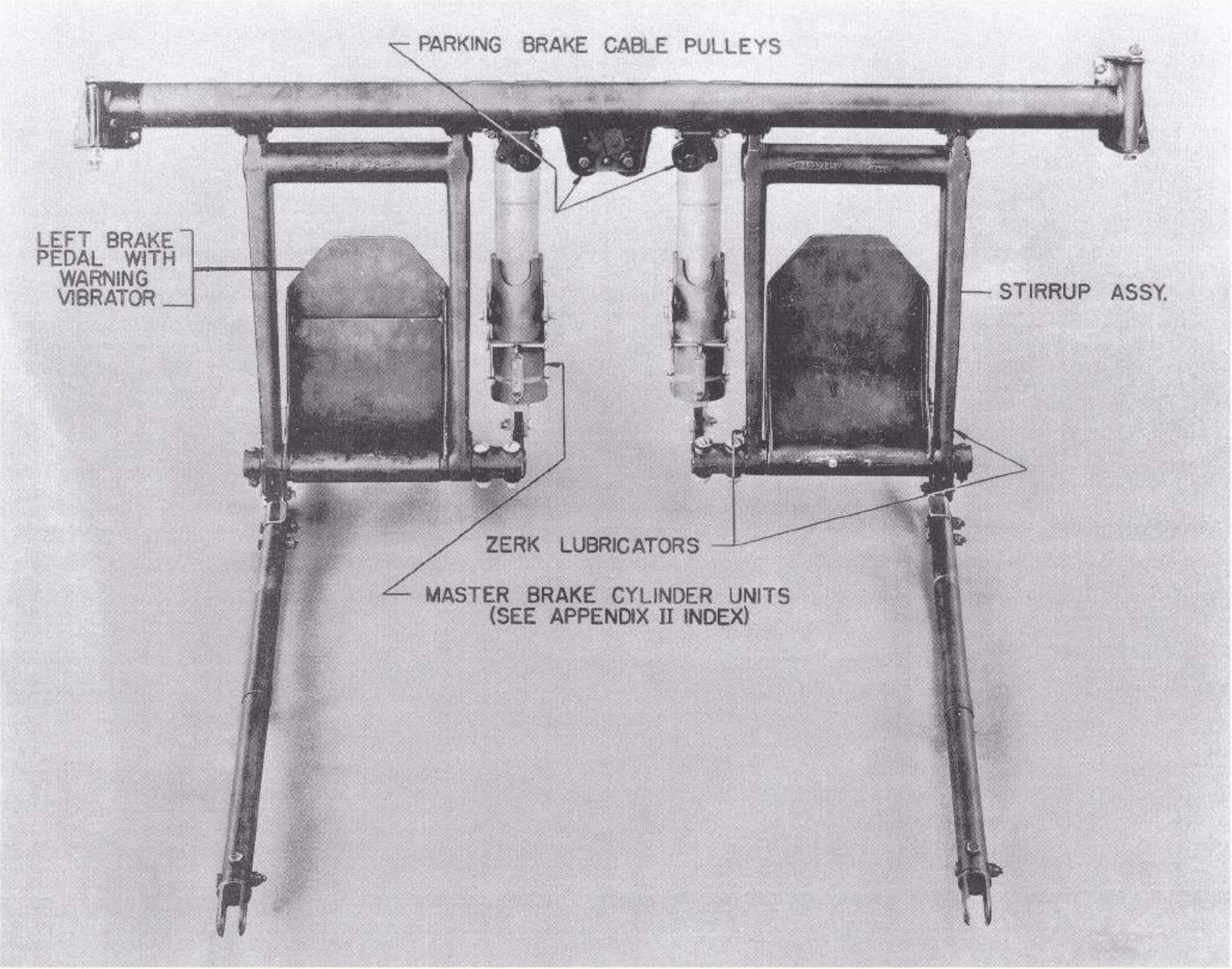
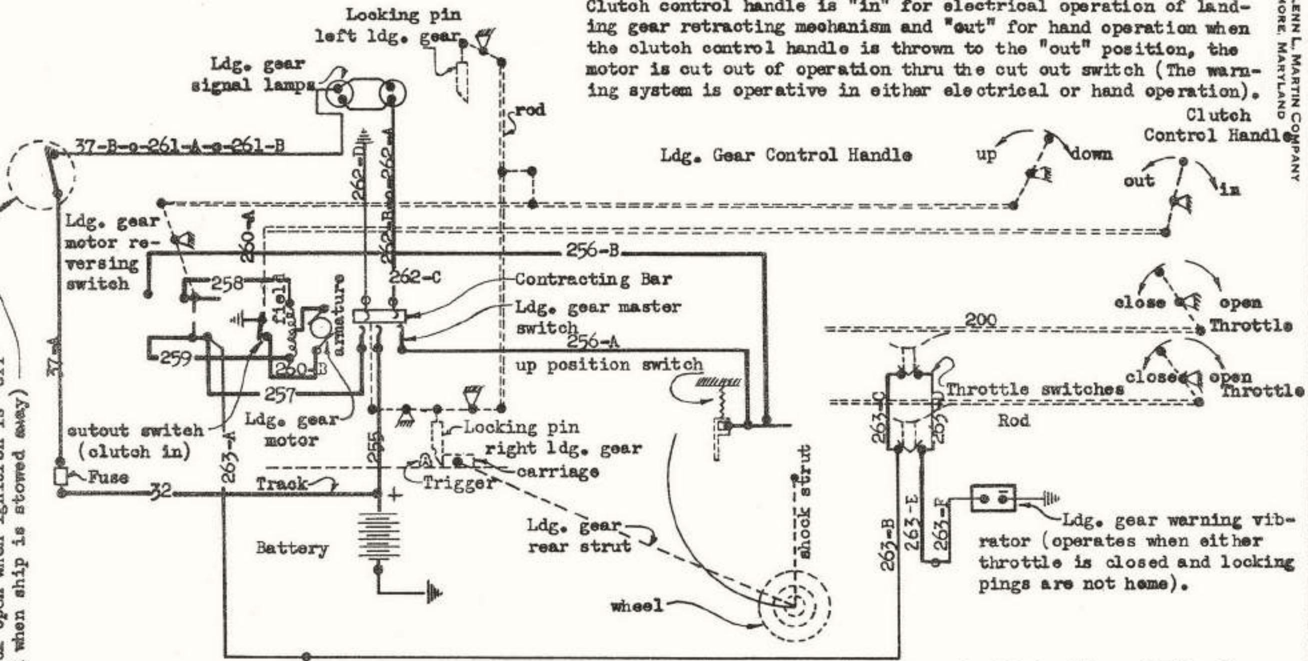


FIGURE 25 BRAKE PEDAL ASSEMBLY



Ignition switch interlock open when ignition is "off" (prevents battery drain when ship is stowed away)

FIGURE 36

DIAGRAM - OPERATION OF LANDING GEAR ELECTRICAL INSTALLATION

Landing gear in down position (Landing or ship on ground with ignition switch on).

1 - Ignition switch "on".
2 - Ignition switch interlock closed.
3 - Throttle closed.
4 - Clutch control "in".
5 - Ldg. gear control handle in down position.
6 - Master switch open, locking pins home.
7 - "Up position" switch closed.
8 - Reversing switch closed - (To right on diagram).
9 - Landing gear retracting motor stopped. (As soon as lock pins are home).
10 - Signal lamps contacts closed (Lamps on.)
11 - Warning vibrator inoperative.

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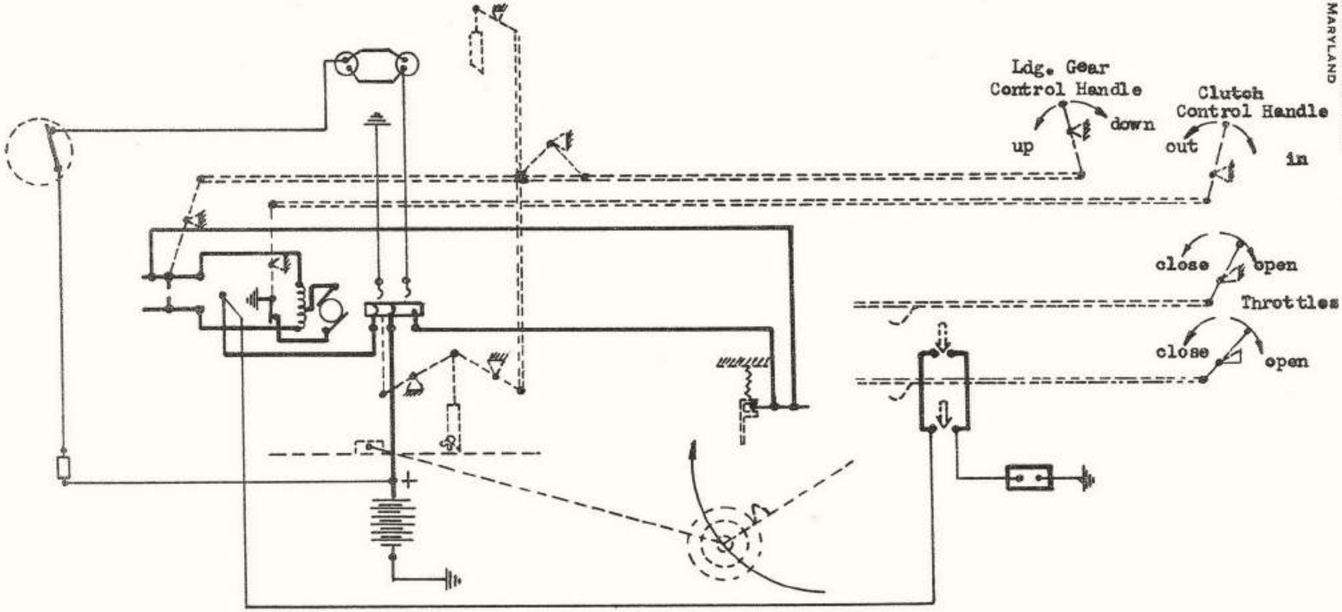


Landing Gear Going Up (Aft Take-off).

1 - Ignition switch "on".
2 - Ignition switch interlock closed.
3 - Throttles open.
4 - Clutch control " in ".
5 - Landing gear control handle in "up" position.
6 - Master switch closed (Held closed by trigger, keeping locking pin up. Short contacting finger makes contact after lockpin clears carriage by 1/16").
7 - "Up position" switch closed.
8 - Reversing switch closed. (To left on diagram).
9 - Landing gear retracting motor running.
10 - Signal light contacts open (lamps out).
11 - Warning vibrator operative. (When either throttle is closed).

FIGURE 36B

DIAGRAM - OPERATION OF LANDING GEAR ELECTRICAL INSTALLATION
(SEE FIGURE 36 FOR COMPLETE DESCRIPTION)

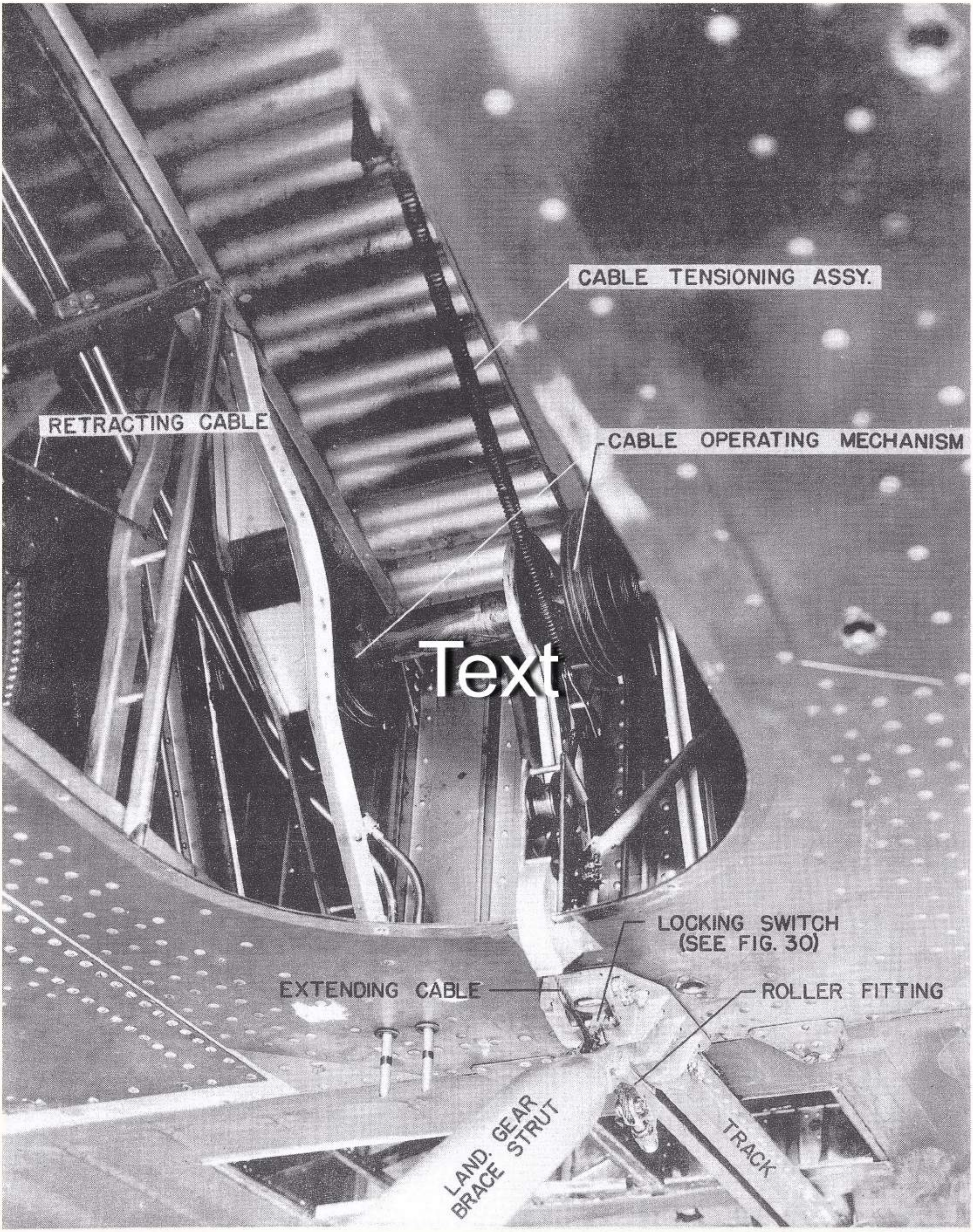


FIGURE 37 RETRACTING SYSTEM IN WING

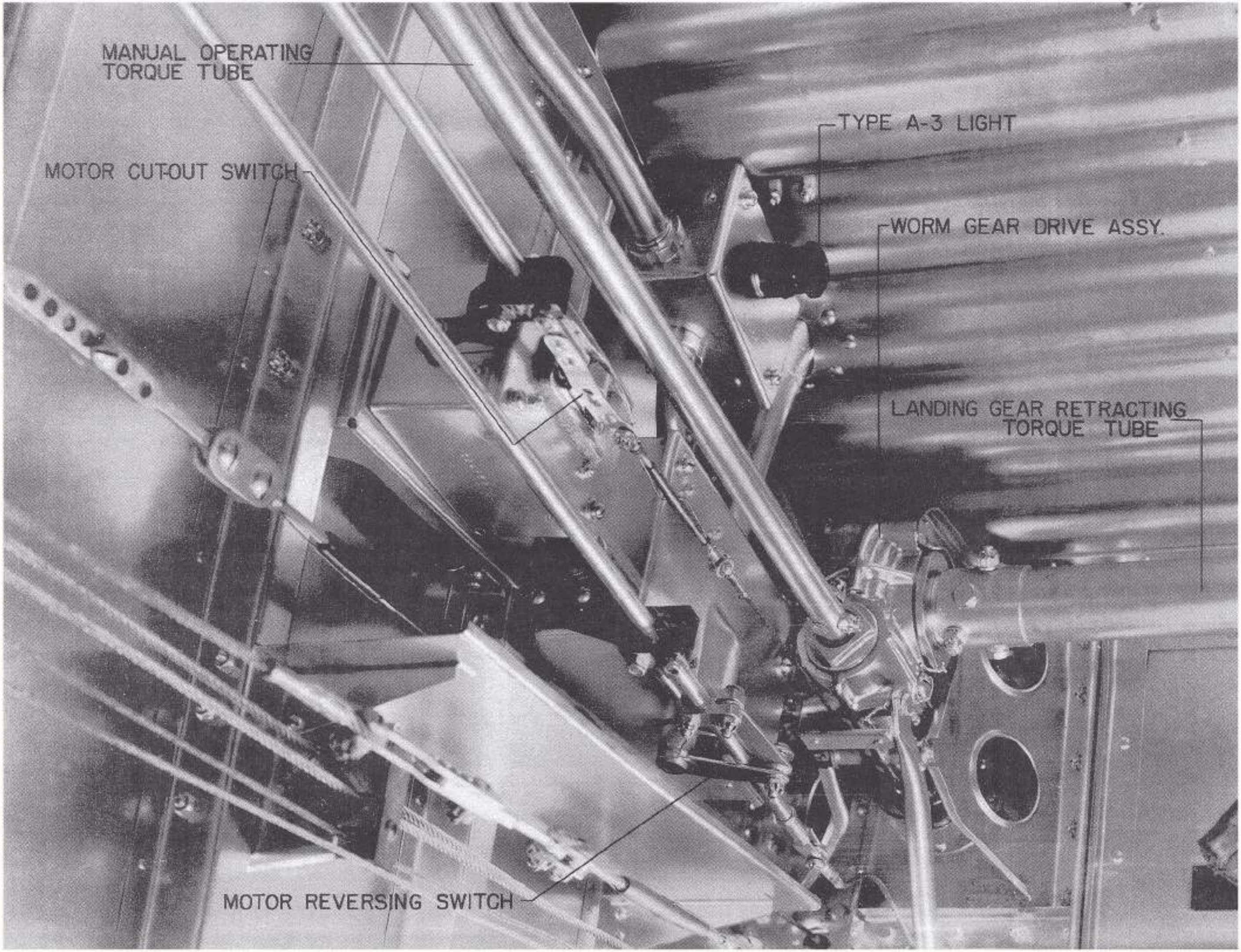
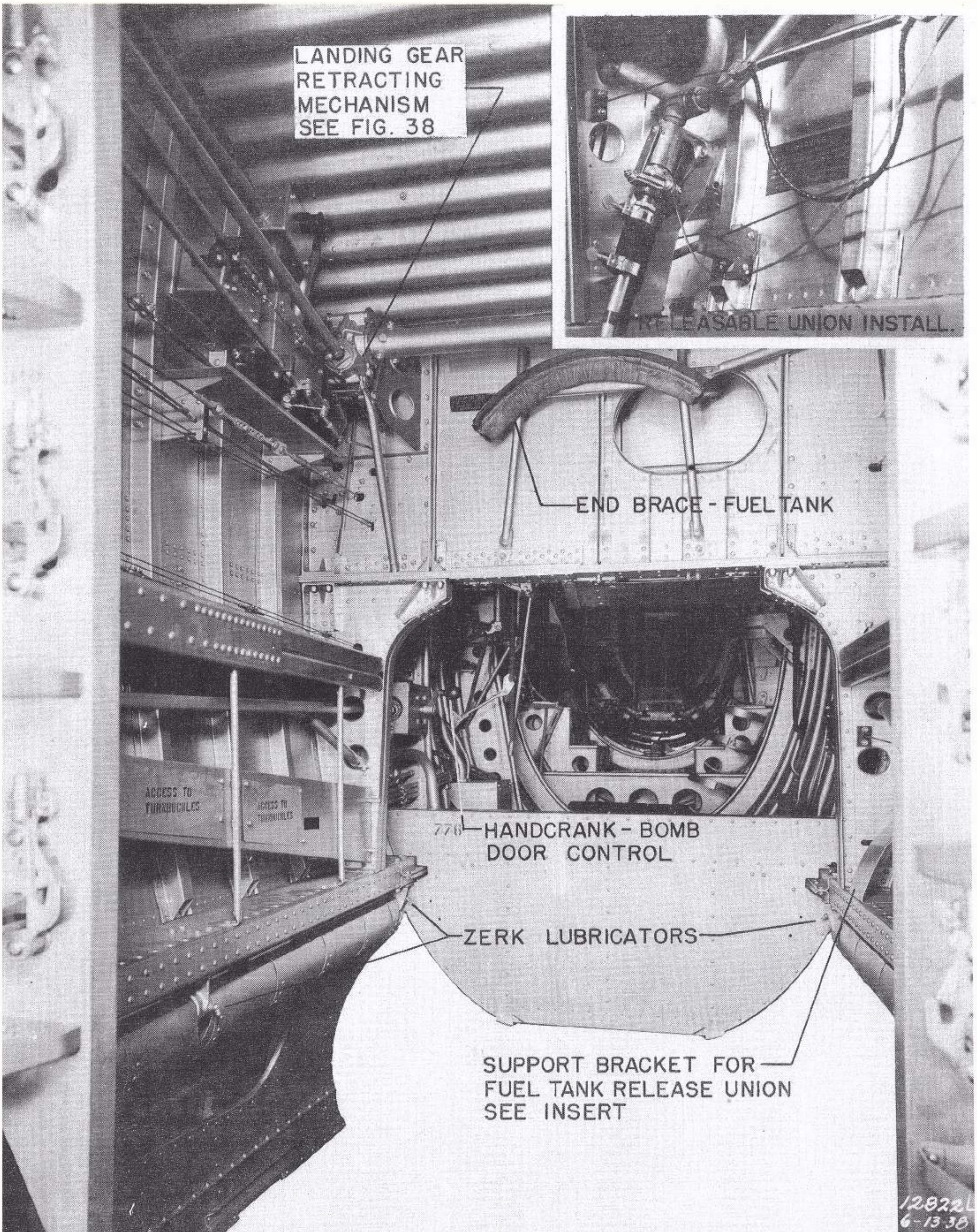


FIGURE 38 LANDING GEAR RETRACTING MECHANISM IN BOMB BAY



C

FIGURE 39 BOMB BAY - LOOKING AFT

C

SECTION X

POWER PLANT

A. General

This airplane is powered by two Wright Model R-1820-G5 ("Cyclone") engines each equipped with a two speed supercharger and an Eclipse Supercharger Pressure Regulator. These engines are rated at 950 B.H.P. at 2200 rpm. at 39.5 in. Hg. and 7.14:1 supercharger gear ratio at sea level, and 750 B.H.P. at 2100 rpm at 33.5 in. Hg. and 10:1 supercharger gear ratio at 15200 feet. Detailed information on the operation of the engines is given in the Special Piloting Instructions, Section II-A. Additional information on the maintenance of the engine and its accessories is contained in the Wright Instruction Manual, and in the Miscellaneous Instruction Books for Airplane Accessories, which are furnished for each airplane.

The engine installation is shown in Figures 41, 42 and 43. The diagrams, Figures 40, 46 and 50 will be useful in removal and installation operations.

B. Unpacking Procedure

1. New Engines

New engines when received direct from the engine manufacturer are enclosed in special boxes and are amply protected from corrosion and dampness by heavy wrapping and oils. To unpack a new engine.

a. Break the seals found under the metal protecting plates at the bottom of the box.

b. Remove the nuts on the bolts found directly under the handles and lift the cover off by the handles.

c. Remove oil cloth and unpack all loose parts attached to the base. Check against the list on the Sales Order and inspect to see whether anything has been damaged in shipping.

d. Remove the dummy spark plugs and rotate the crankshaft ten or twelve times.

e. Fasten the hoisting sling on the engine. Be sure that the cable plates are properly installed. Tighten the Lifting Cable Clamps.

f. Raise the engine and base to a vertical position.

g. Remove the nuts from the bolts holding the steel mounting plate to the base and remove the base. The mounting plate can then be removed from the engine.

h. Loosen the intake pipes of the lower cylinders and draw them out of the cylinders to allow the oil in the pipes to run out. Turn the crankshaft slowly several times to facilitate draining the preservative compound. This can be done by inserting a bar through the holes in the propeller shaft. By sight, or by feel with a device such as a long striping brush having well secured bristles, determine the condition of the cylinder walls to make sure no rust exists. See Wright Instruction Book for disassembly procedure.

i. When oil has been drained and the engine is cleaned and inspected, tighten the intake pipes at the lower cylinders.

2. Engines from Airplane Manufacturers

a. The engines received from the airplane manufacturer have been completely assembled in the airplane and test run. In order to conserve space in shipping and assembly time after received, certain accessories not installed on the engine when delivered from the Wright factory have been left installed by the airplane manufacturer. For this reason the procedure for unpacking the engine will be slightly different in this case.

b. The engine is reshipped in the original box and the unpacking is accomplished in a like manner to a new engine. The rust preventative oil coating may be left on the outside since it serves as a protection against dampness and corrosion while the engine is being installed.

c. Follow instructions outlined in paragraphs(a)through(h)for new engines, paying particular attention to paragraphs (h) and (i).

C. Installation Procedure

To facilitate the installation of the engine in the mount, various parts must be removed. These parts were temporarily replaced on the engine for shipment by the airplane manufacturer.

1. Remove the outboard plug at the bottom of the oil pump.

2. Remove the top bolt in the cover plate at the gun synchronizer drive. This is done on the left side only for both engines.

3. Remove the Cuno oil strainer.

4. Remove from the right hand engine only the street ell fitting for the oil vent line located directly above the gun synchronizer at the outboard side of both engines.

5. Remove the radio shielding housing from the right-hand magnetos (both engines), and lay the rotor block back against the starter. The adjacent bonding connector must be loosened and moved under the Breeze shielding of the magneto.

6. Remove the drain plug and stem from the bottom right side of the supercharger housing.

7. Protect the Breeze ignition shielding with a suitable cover to prevent damage at installation of the engine.

8. Install the Starter and Generator. A supporting bracket is provided between these units to provide greater rigidity. It is essential that this bracket be properly installed without strain between the accessories. Care was taken at the factory to remove it without changing the adjustment. However, if it is necessary to readjust, the above conditions must be met.

9. Install the front and rear engine cowling support rings on the lugs of the engine rocker boxes. The rear support ring also consists of the cowl flaps. The installation is described in Section VIII.

10. Install the exhaust manifold nipples at the engine exhaust ports, except on No. 1 cylinder. (See paragraph E.) Caution: Remove the cover plates from the ports first.

11. Be sure the small brass elbow located below the engine mounting lug aft of cylinder No. 9 and used for the engine primer line is turned aft. This fitting is hard to reach when the engine is mounted.

12. The engine mounts are removed from the wing with as many parts intact as is practicable. It is therefore, only necessary to make the proper connections of those parts after the engine is installed in the mount. This pertains mostly to electric conduits to junction boxes, brackets, and such flexible controls as can be conveniently disconnected at the engine and at the wing spar.

The mounts are shipped with the exhause manifold "muff" and carburetor hot air duct intact. The engine mounting bolts are also left installed in the mount together with the engine baffle plates.

13. Remove the baffle plates and properly place the steel counter-sunk washers on the bolts.

14. With the engine suspended by the sling and rigidly supported, lift the engine mount into position and start over the impeller housing.

15. With the rear end of the engine through the mounting ring the baffle plates should be installed in the proper places. Guide the braided flexible pipe from the intake into the magneto blast tube - both sides of the engine.

16. Provide one aluminum alloy spacer washer on each mounting bolt at the front side of the baffle plate and guide the bolts into the engine mounting lugs. The nut on the bottom bolt must be installed first before too much bolt extends through the lug. One aluminum alloy spacer washer and three steel washers are used under the nuts for all bolts. As the mount is moved toward the engine, continue to draw up on the bottom nut.

17. Place spacer-washers and nuts on all bolts and draw up reasonably tight with the special (12 point) box wrench No. A-210309.

Note: If the engine mounting bolts have been disassembled from the engine mount for any reason, it is essential that they are replaced in accordance with the instructions in paragraph "D" of this Section.

18. Replace the shielding on the magneto; the Cuno oil strainer; the plate bolts in the synchronizer covers; the plug in oil pump; the oil vent fitting on the right engine; and the supercharger drain fitting.

19. Install the carburetor throat adapter, and the carburetor. Provide the proper gaskets and wire screen, and install the carburetor heat control valve. (See Parts Catalog for Wright Cyclone R-1820-G Engines for the order of locating the various parts of this assembly.)

20. Install the tachometer and fuel pump drive adapter on the right side of the engine. Install the tachometer generator and the fuel pump, and safety in place.

21. Connect the engine primer line. Make sure the clamps are secure,

22. Connect the carburetor drain lines at the fore and aft sides of the carburetor. Connect the ram line at the front side of the carburetor.

23. Install the electrical conduit for the temperature indicator at No. 1 cylinder.

24. Install the electrical conduit to the propeller motor brush housing connecting the attached bonding cable at the aft side of the baffle plate.

25. Connect the heavy bonding between the engine and engine mount (both sides).

26. Connect the cowl flap push rods to hold the flaps open.

27. Install the exhaust manifold sections. The exhaust gas analyzer nipples must be removed from the bottom left section in order to install. Replace nipples and connect the sampling and expellant lines. (See paragraph J.)

28. Install the Servo oil pump and the vacuum pump at the right side of the left-hand engine and install the vacuum pump on the right engine.

29. Make the electrical connections between the engine accessories and the junction box at the right side of the engine mount.

30. Install the engine instruments on the shock absorbers at the inboard side of each mount, and make the proper connections.

31. Connect the control rod between the carburetor and the supercharger regulator lever.

32. Connect the drain lines from the supercharger housing, carburetor, and vacuum pump.

33. Make a thorough inspection of the assemblies to ascertain that no bolts or nuts are missing and that all are safetied.

34. Hoist the engine mount into position on the wing and secure in place with the attaching bolts. (Refer to Section VIII for the attachment of the mount to the spar.) Replace the phenol fiber covers around the lower legs of the engine mount frame at the fire-wall.

35. Connect the Servo oil lines between the engine accessories and the oil sump, and the pressure regulator.

36. Connect the propeller governor drive at the adapter on the engine oil pump.

37. Connect the fuel pump drive shaft.

38. Install the oil lines at the pump and install the temperature bulb in the well of the "OIL IN" line.

39. Install the control cables to the cowl flap drive unit located at the bottom of the engine.

40. Connect all engine controls and safety.

41. Install the propeller. See paragraph K.

42. Check the installation of all bonding jumpers.

43. Install the spark plugs last in accordance with the instructions given in Chapter VII of the Wright Instruction Manual. Make certain that the spark plugs will function properly before they are screwed into the engine. Spark plugs that are not stored in dry air-tight containers are affected by condensation and do not function properly. See Engine Maintenance, paragraph M.

44. After all installations are passed final inspection, fill the fuel and oil tanks and the Servo oil tank to the proper levels before starting the engine run-up check.

45. Refer to the Pilots' Instructions (Section II-A) for Starting and Operating the engines.

D. Engine Mounting Bolt Assembly

1. The engine is installed in the mount on 9 tee type Lord rubber shock absorber bolt assemblies. Three of these units are equipped with adjustable-stop assemblies to eliminate torsional play between the mount and the engine. The component parts of these assemblies are shown in Figure 27. The engine mounting lugs, which are welded on the engine mount ring adjacent to cylinders No. 1, 4 and 7, are spaced for these units. The remaining six pairs of lugs do not have sufficient space between for the adjusting nut unit.

2. The rubber core of the Lord mounting bolt has been inserted from the faced off side of the metal housing. The bolts must be installed in the mount so that the location of these machined surfaces correspond with the direction of engine rotation. That is, the machined surface of the top bolt will be at the right side looking at the engine from the rear.

3. Flanged spacer-bushings are inserted into the Lord unit from both sides. See Figure 27. The long spacers are used through the three adjustable-stops only. All other spacers are short.

4. Starting at the top cylinder No. 1, the five right hand AN-5/16 attaching bolts through the engine mounting lugs and the Lord unit,are inserted in a clockwise direction.

The remaining four bolts at the left side of the engine starting aft of cylinder No. 9 are inserted in a counter-clockwise direction.

This is done so that these bolts will be more apt to remain in place if the nuts were accidentally left unsafetied.

5. The three adjustable units are installed as follows:

a. Line up the Lord unit, adjustable-stop assembly, and spacers in the manner shown in Figure 27. Place the adjustable-stop assembly against the machined surface of the Lord unit.

b. Install the assembly in engine mount lugs with the adjusting unit on the side corresponding to the rotation of the engine. See "Adjustable Mounting Bolt," Figure 29C. Insert the AN attaching bolt in the proper direction. Washers and spacers used under the head and nut of the attaching bolts are shown on the Engine Installation Drawing which is listed in Appendix III.

c. Line up the threaded bushing in the adjustable-stop unit with the No. 10-32 drilled head bolt in the engine mount lug and screw the bolt in far enough to hold the bushing flange.

d. Adjust the unit until it bears snug against the Lord unit, but do not overtighten.

e. Screw the No. 10-32 locking screw through the flange into the nearest hole in the adjustable-stop unit and safety with .041 lockwire.

E. Exhaust System

1. Description

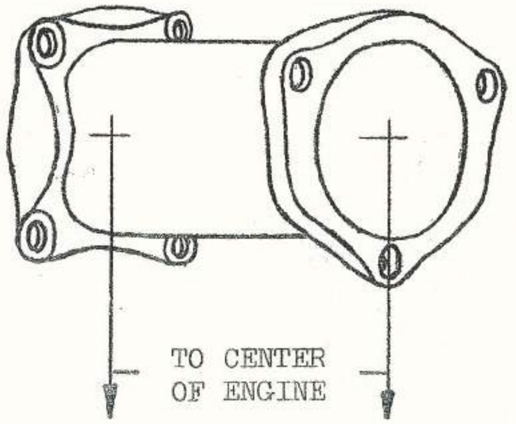
The engine Exhaust Manifolds are manufactured by the Solar Aircraft Company, San Diego, California. Corrosion-resistant sheet steel, AC Spec. No. 57-136-9, 1st grade, is used in the fabrication of the Manifold.

The exhaust system comprises two separate collector assemblies, each having its outlet terminating below the engine nacelle. The right-hand assembly is connected to four engine cylinders, Nos. 2, 3, 4 and 5, while the remaining five engine cylinders, Nos. 6, 7, 8, 9 and 1 are connected to the left-hand assembly. There are four main sections in each assembly. The sections are assembled together by means of special clamps as shown in Figure 42. (See paragraph 2.)

The sections of the manifold (except the top left section at cylinder No. 1, which connects direct) are supported on the engine by eight short nipples, (see sketch below). This construction is provided mainly for the removal of an engine cylinder without removing the exhaust manifold. Since they can be made heavy at the section most stressed, the nipples also reduce the possibility of failure of the outlet pipes due to fatigue, or to disintegration caused by direct subjection to the exhaust blast.

2. Installation

The nipples shown in the sketch are similar parts and must be installed on the engine so that the three-hole flange will coincide with a similar flange on the corresponding manifold section. That is, the nipple must be installed on each cylinder so that the bolt hole shown on the imaginary indicator lines in the sketch below will be nearest the center of the engine.



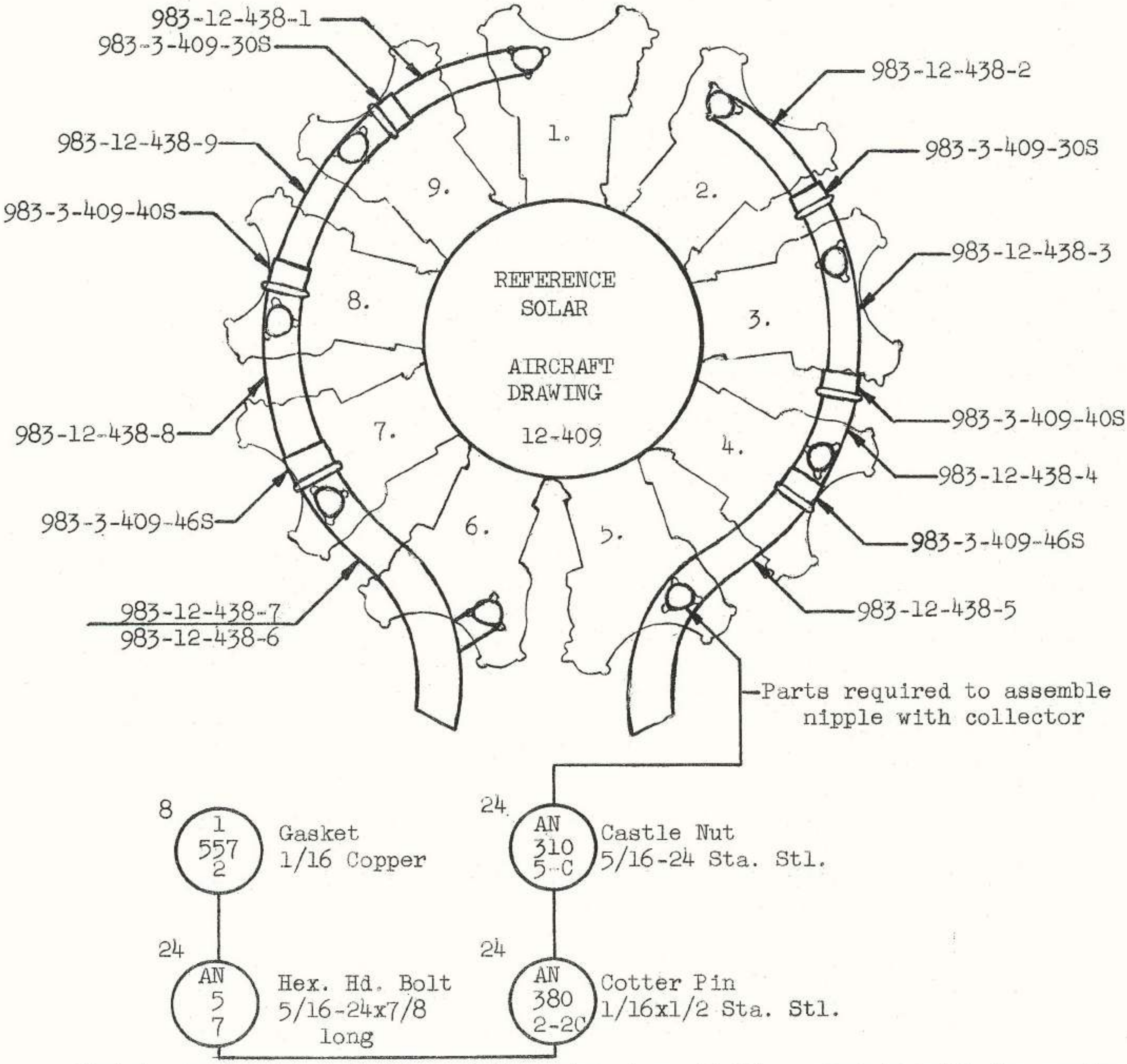
NIPPLE BETWEEN ENGINE AND
EXHAUST MANIFOLD

INSTALL PART NO. 983-1-625-2S
AT CYLINDERS 2-3-4-7-8-9.

INSTALL PART NO. 983-12-438-10
AT CYLINDERS 5 AND 6.

These parts are most easily installed when the engine is suspended in the hoisting sling prior to assembling with the engine mount. A copper-asbestos gasket is placed between the engine exhaust port and the nipple, and a solid copper gasket is used between nipple and collector.

The exhaust manifolds are installed after the engine is secured in the engine mount. The accompanying sketch indicates the proper locations of the manifold components.



Sketch showing the relation of the exhaust manifold components with the engine.

It is necessary to remove the two stainless steel nipples for the Cambridge Analyzer to install the bottom left section of the exhaust manifold. Further details on the analyzer connections are contained in paragraph J of this Section.

When installing the manifold, begin at the top (either side) and work down. The nipples having been already installed need not be considered. The parts required for assembling the manifold together, and installing them on the nipples are shown in the above sketch. The sleeve-bands which are clamped over the joints should not be drawn up too tightly. They should be snug, but still free enough for rotation when gripped with both hands.

Whenever the exhaust manifold has been removed from the engine, a thorough inspection of all the parts should be made for cracks or fractures. Check the copper asbestos gaskets between the engine exhaust parts and nipples, replacing any that show signs of failure.

F. Air Intake System

1. General Description

In general, the carburetor air intake system for each engine consists of a hot and cold air "mixing chamber" or "heat control valve" which is mounted on top of the down-draft carburetor, and connected by separate ducts to the air supply. See Figure 43. Cold air is obtained by "RAM" through an air duct integral with the top section of the engine cowl, and which connects the forward side of the heat control valve. Hot air is drawn from the "Muff Assembly Well" where it is pre-heated by the exhaust manifolds, and is conducted into the heat control valve through two inter-connected air ducts shown in Figure 43. The pre-heated air is first drawn through a $\frac{1}{2}$ inch gap provided between the front plate of the muff assembly, and the inner periphery of the venturi cowl, and thence through the ducts connecting the heat control valve with the top of the muff well.

A special thick, woven, sealing gasket is provided between the air ducts and the heat control valve unit to eliminate leakage in the system. The front seal is retained by flanges integral with the valve unit and remains in place when the top section of the engine cowl is removed. The rear seal is retained between the heat control valve unit and the hot air duct in a semi-floating condition, being held in place by flanges provided on each unit. See Figure 43. This seal can be removed only after the hot air duct is disassembled from the rear side of the muff where it is secured by sixteen No. 10-32 steel bolts and castle nuts.

The heat control valve is operated by means of an adjustable type control handle which is located aft of the throttles on the left side of the cockpit. This handle is connected to the valve unit on each engine by a system of push rods and levers shown in Figures 40 and 4.

2. Heat Control Valve Mechanism

The heat control unit is shown on the Engine Installation Drawing. The housing is fabricated from corrosion-resistant sheet steel using spot-welded construction. The mixing chamber is equipped with a flapper valve which is constructed of aluminum alloy sheet reinforced by corrugations. The valve gate is loosely hinged on a control shaft which passes through the housing. Two stop plates are bolted onto the shaft so as to extend down the rear side of the gate, thus preventing the gate from swinging back uncontrolled. A special coil spring is retained on the shaft, and extends downward at the front side of the gate keeping it pressed against the stop plates. This spring permits the gate to rotate forward on the shaft in event the engine backfires through the carburetor, thus allowing the back pressure to escape through the cold air duct.

The valve gate shaft is supported by two ball bearing assemblies which are mounted on the outer sides of the valve unit housing. These bearings are retained in their housings by dust-tight caps which are removable to permit disassembly of the valve gate. Serrations are provided on the faying surfaces of the valve gate shaft and the control crank to permit initial adjustment of the gate and controls.

G. Engine Controls

The Engine Controls are shown in the Diagram, Figure 40, with details shown on the Eng. Control Installation Drawing.

In general, the system consists of a complete set of controls terminating at the left side of the pilots' cockpit with partial control installed in the rear cockpit. Except for the Shakespeare controls used in the supercharger regulator system and the supercharger speed control system, the engine controls are operated through a system of push-pull rods. These rods and controls are equipped with self-aligning and sealed ball bearings wherever a change in control direction is necessary. The terminals are generally ball-bearing except in a few cases where clevis terminals are used satisfactorily. The sealed ball bearings need no further lubrication, but the self-aligning bearings, open bearings, and clevis terminals must be oiled or packed with light grease at overhaul and inspection periods as required. See grease charts in Appendix IV.

The pilots' engine controls consist of a modified Type B-6 engine control unit in which two supercharger regulator control levers are incorporated; also an adjustable unit combining the controls for the carburetor air temperature, and the engine two-speed supercharger. The engine control unit provides for the throttle and mixture controls in addition to the supercharger control. The spark adjustment is locked in the full advanced position on the engine and no means of control from the cockpit is provided. The two-speed supercharger control handle is connected to the engine units through Shakespeare controls. Two positions, "High" and "Low" are provided in the handle which is located inboard nearest the pilot. The carburetor heat control handle is provided with a ratchet and lock by which the valve unit on the engine may be adjusted at various degrees open.

A diagrammatic layout of these controls is shown in Figure 40. The Engine Control Installation drawing is listed in Appendix III.

The copilot's controls consist only of a throttle for each engine and one mixture lever incorporated in a standard Type B-1 engine control unit which is located on the left side of the fuselage. The push-pull control rods are connected to the bellcrank assembly located on the front wing spar in the pilots' cockpit (see Figure 4). The one mixture control is so arranged that the copilot can richen the mixture only, thereby preventing him from damaging the engines by "leaning out" the mixture without being able to observe the tachometers and manifold pressure gauges located in the front cockpit. The extra mixture lever is part of the standard control unit, but is not connected to any part of the engine. It is kept in one position by means of lockwire. The arrangement of this mechanism is shown on the Engine Control Installation Drawing, and in Figure 40.

Adjustments of the control rod lengths to synchronize the movement of all the throttle, or mixture levers can be made by backing off the locknuts from the rod ends, adjusting the length by turning the terminal in the desired direction, and retightening the locknut. It should be noted that the throttle controls are arranged to transmit a differential motion to the butterfly valve in the carburetor, thus permitting finer adjustments near the closed position.

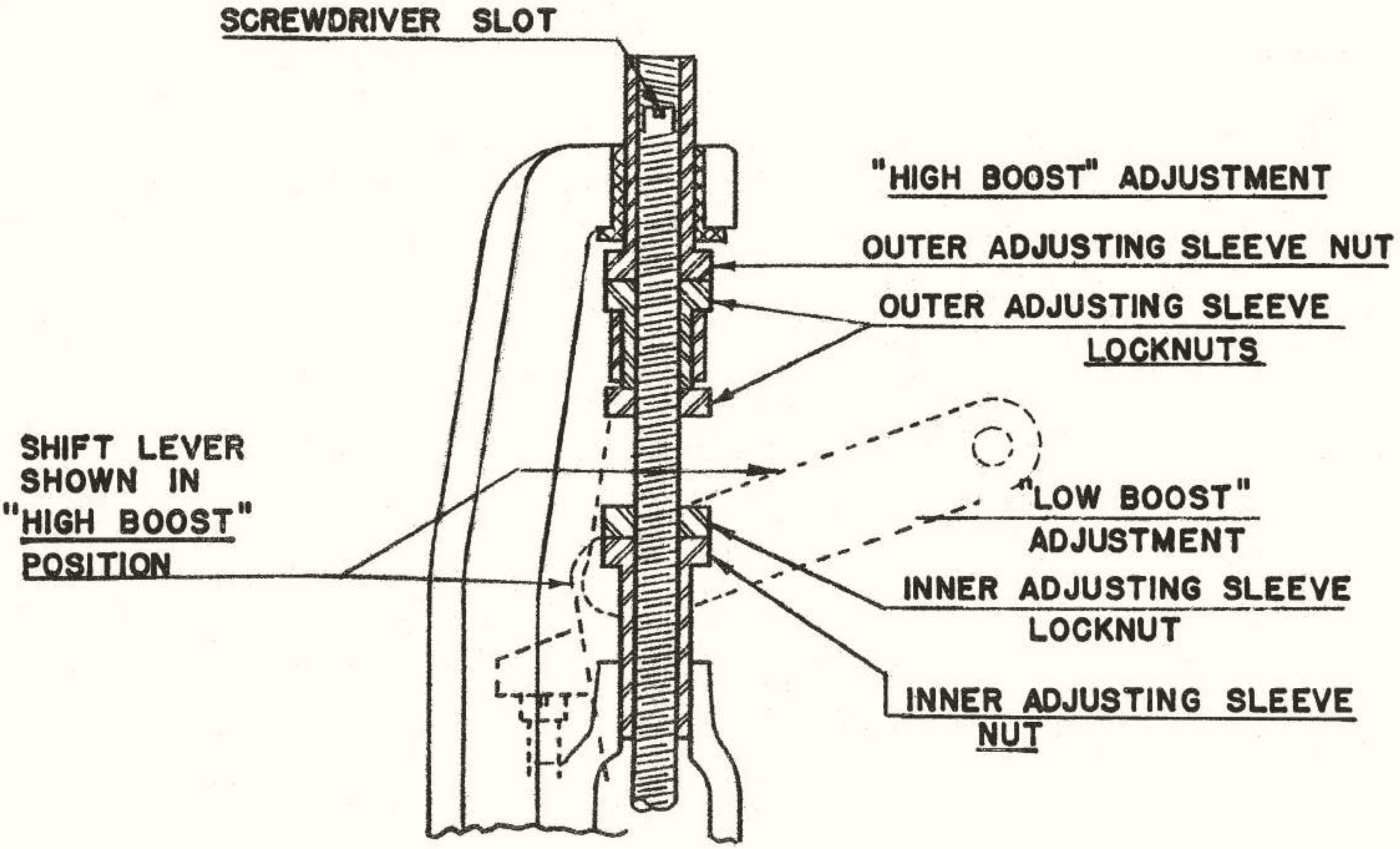


FIGURE 39-A
ADJUSTMENT DIAGRAM FOR ECLIPSE SUPERCHARGER PRESSURE REGULATOR

H. Supercharger Regulator System

1. General

The rated power of the engines at varying altitudes is maintained through the control of the engine manifold pressure by means of an Eclipse Supercharger Regulator which is installed on the engine. These regulators will automatically maintain any desired manifold pressure between the high and lower power limits of the engine as adjusted by the pilot. These units are controlled by the pilot by means of two levers incorporated in the Engine Control Unit, and connected to the regulators through "Shakespeare" controls (see Engine Control Diagram, Figure 40). The regulators are interconnected with the engine carburetor controls in such a way as to provide for sufficient overcontrol of the regulator to permit full-throttle operation with the regulator piston in the "FULL OUT" position. The Eclipse Supercharger Regulator Instruction Booklet No. 38 which accompanies each airplane shows the required travel of the lever connecting the regulator to the cockpit control to permit overcontrol of the regulator.

The two levers provided to operate the pressure selector lever on the regulator are installed with sufficient friction to hold the lever in any position within the operating range.

Because it is extremely important that the supercharger regulator be properly adjusted when operating the engines in flight, the following instructions repeated here are taken from the Wright Aeronautical Corporation Miscellaneous Instructions, No. 103-B (Revised March 10, 1937); and Eclipse Instruction Booklet No.38.

2. Adjustment-Eclipse Supercharger Regulator

(a) Control Linkage

Since the linkage from the regulator to the carburetor is installed in accordance with the installation drawing (page 11 of the Eclipse Booklet) the only adjustment will be a possible adjustment in the length of the link rod. With the throttle fully CLOSED and the regulator piston FULL IN, the carburetor lever and the corresponding lever on the regulator should both be approximately 30° above the horizontal.

(b) Regulator Adjustment

(1) High Boost The high boost take-off manifold pressure ($39\frac{1}{2}$ in.-- 100.3 cm. Hg.) should be obtained from the engine specification. With the pressure selector lever in the "High Boost" position, start the engine in the normal manner (paragraph D, Section II-A), using the throttle to control the engine speed during the warm-up operation (see paragraph E, Section II-A). When the engine is thoroughly warmed up, the throttle lever in the cockpit should be moved slowly towards the open position. Do not exceed take-off manifold pressure. If the regulator adjustment is too low, a limiting manifold pressure will be reached and movement of the throttle lever towards the throttle closed will not change the stabilized pressure. If the adjustment is too high, the take-off manifold pressure will be obtained before the throttle reaches the end of its travel. If an adjustment of the setting is necessary (refer to the adjustment diagram, page 1009), loosening the outer adjusting sleeve lock-nuts and screwing the outer sleeve toward the regulator body will increase the manifold pressure setting approximately $\frac{1}{2}$ inch Hg. for each full turn of the sleeve. Following this adjustment, the engine should be run and the pressure checked as explained above. Any further variance from the desired take-off

manifold pressure can be corrected by further adjustment. The lock-nut should be tightened securely after the final adjustment is made. During the check the R.P.M. should be the desired take-off R.P.M. Although lower R.P.M. will not affect the adjustmentprocedure or the final adjustment, it may induce detonation and its accompanying detrimental effects.

(2) Low Boost With the pressure selector lever in the extreme low boost position, the manifold pressure should not exceed 20 in.--51 cm. Hg. when the throttle is opened until the engine is turning at approximately recommended cruising R.P.M. Normally the regulator should require no adjustment for the low-boost setting since this is established at the Eclipse Factory. However, if the low boost setting is below or above 20 in.--51 cm. Hg., then an adjustment should be made. Reference to the adjustment diagram indicates that loosening the inner adjusting sleeve lock-nut and screwing the inner adjusting sleeve outward from the regulator body will decrease the manifold pressure setting approximately $\frac{1}{2}$ inch Hg. for each full turn of the sleeve. Following the preliminary adjustment, the setting may be checked and further adjustment carried out as necessary. The lock-nuts should be securely tightened after the final adjustment.

For complete instructions on the operation of the engines with the supercharger regulators, see the Special Piloting Instructions (Section II-A of this Manual), or refer to the Pilot's Operating Manual. Additional information on the maintenance of this accessory may be obtained from the Eclipse Aviation Corporation Instruction Book No. 38 covering the Supercharger Regulator for Wright Cyclone Engines, a copy of which is included with the accessory bulletins.

I. Supercharger Speed Control

The two speed supercharger controls with which this airplane is equipped provides gear ratios of 7.14:1 in low blower, and 10.0:1 in high blower. This equipment effectively combines both low and high altitude characteristics in the same engine.

This unit is used in direct drive and reduction geared engines. It is hydraulically operated by engine oil to shift the impeller gearing into either high or low as desired. It takes the place of the solid type impeller drive gear, and impeller drive gear shaft which are used in single speed supercharger engines. The only external difference is the presence of a small plunger type control located on the rear cover above the generator pad which actuates the hydro valve controlling the two speed unit.

The two speed supercharger unit consists essentially of a high ratio layshaft in which is incorporated a small planetary reduction gear which, when engaged, reduces the unit to the low speed ratio. Oil pressure at the control valve may be applied by actuating the plunger to the high gear hydro clutch at the forward part of the unit or to the low gear clutch at the rear of the unit. When the control valve is moved to the neutral position, the oil pressure on both the hydro clutches is relieved, thus making the impeller drive inoperative. The control valve should not be left in the neutral position during flight operation.

The high gear ratio is obtained by means of oil pressure on the forward clutch which is incorporated in the impeller drive gear which replaces the solid type impeller drive gear used in engines having single ratio supercharger gears. With the unit in high ratio the stationary or sun gear of the low ratio planetary gear train is free, because the low ratio clutch is disengaged, and it rotates with all of the layshaft parts. In the high ratio, therefore, the drive is as follows: (a) From the accessory drive gear to the intermediate impeller drive gear (b) From the intermediate impeller drive gear through the front, or high ratio, "engaged" clutch and impeller drive gear to the impeller shaft.

The low gear ratio is obtained by means of oil pressure on the rear or low ratio clutch which anchors the sun or stationary gear of the planetary gear train. The high ratio clutch is disengaged and the planetary gear train becomes operative changing the supercharger gears into the low ratio. In the low ratio, therefore, the drive is as follows: (a) From the accessory drive gear to the intermediate impeller drive gear (b) Through the planetary gear to the intermediate drive shaft (c) From the intermediate drive shaft which is splined to the impeller drive gear at the forward end, to the impeller shaft.

HYDRAULIC SYSTEM In two speed supercharger engines a drilled passage leads from the crankshaft extension bearing to a control valve located in the supercharger rear housing cover at the rear end of the impeller drive shaft. When the valve is in the high speed position oil under engine pressure is admitted through the oil distributor plug, which is pinned in the bore of the intermediate impeller drive shaft, to the chamber between the impeller drive gear and the high speed clutch piston, and the passage from the low speed clutch piston is open so that oil in the chamber between the low speed clutch piston and the supercharger rear cover is free to drain into the crankcase. When the control valve is in the low speed position, oil under engine pressure is admitted to low clutch piston chamber. When the valve is in the neutral position, oil pressure is admitted to neither clutch piston chamber. Passages are provided in the intermediate impeller drive shaft to conduct oil to the pinion and sun gear bushings and to the impeller drive gear bushing in the supercharger rear housing.

Additional information covering the construction and maintenance of the unit are included with the Wright Aeronautical Data in the Miscellaneous Bulletins.

It is extremely essential that the Shakespeare controls for both units are adjusted for synchronous operation. A clevis terminal is provided at the unit end of the controls at which the stroke adjustment is made. There should be 1/8 inch extra travel in both directions over the 1/2 inch required in the stroke adjustment. This will assure full travel of the plunger and compensate for any friction that may exist in the Shakespeare controls.

J. Exhaust Gas Analyzer

1. General

The Cambridge Aero Exhaust Gas Analyzer and Mixture Indicator is installed to more efficiently indicate the fuel/air mixture ratio in either engine and to replace the old method of leaning out by watching the tachometers and engine temperature gauges. Since the engine speed is not affected by a change in power which is due to the action of the constant speed propellers, the conventional method of manual mixture adjustment is slower and less accurate.

The system consists of a gas analyzing cell mounted in the nose section of the wing, inboard of each nacelle and connected by gas sampling tubes to the left-hand exhaust collector manifold; a junction box installed in the pilot's cockpit below the throttle; and a dual type indicator instrument located in the lower left corner of the instrument main panel.

The installation of this equipment is covered on the Installation drawing and in Figures 4 and 4A. The electrical connections are shown on the Simplified Electric Wiring Diagram, Figure 67.

2. Analysis Cell

The cell is mounted on "Lord" rubber shock units in a bracket installed in the nose of the wing. The cell is reached by removing the lower inboard section of the venturi cowling. A shell is installed over the cell unit and is provided with a large cold air blast tube connected to the air intake duct of the oil cooler. Access to the analysis cell core is provided through a removable cover on the shell without disassembling the complete shell installation. Two separate lengths of 3/8" diameter copper tubing connecting the analysis cell to the exhaust manifold are clamped to the nacelle structure and terminate in stainless steel nipples installed in the manifold. The nipple for the sample intake tube is installed so as to point up into the exhaust stream thus assuring a positive flow of exhaust gas through the cell at all times. The nipple for the expellant tube is installed below the intake nipple and pointed down-stream. The tubing for this line is installed in such a way as to insure proper drainage of condensate through the cell and the outlet nipple. Careful inspection of the tubing connections must be made at regular periods to ascertain that they are intact and secure.

3. Procedure for Setting the Cambridge Exhaust Analyzer

There are three points of instrument adjustment which are as follows:

a. Mechanical Adjustment

When the switch marked No. 1 in the junction box, which is mounted in the left side of the pilot's cockpit, is in the "OFF" position, the pointers in the pilot's instrument should both stand at the line marked "A" on the scale. If they do not, the pointers should be brought to this position by turning the small adjusting screws (#2) just above and below the scale.

b. Current Adjustment

A current of constant value is required for proper operation. This is obtained by turning the switch marked #1 to "STD" whereupon the upper pointer should move to the line marked "B" on the scale. If it does not, it is adjusted to this point by turning the rheostat screw #4 on the junction box in the pilot's cockpit.

c. Electrical Zero

The position of the pointer on the electrical zero is the same as the mechanical zero and seldom requires adjustment, but each analyzer cell must be adjusted individually. To adjust:

First verify adjustment a and b. If the adjustment is satisfactory, proceed as follows:

(1) Replace the bronze wool in the analyzer cells with a clean rag moderately wet with water and secure the filter cover. There should be only pure air in the meter and no residual gas from a previous engine run.

(2) Allow the instrument to stand thus for about 30 minutes and then turn the switch marked #1 to "ON," whereupon the pointers should settle at the line marked "A" after 30 seconds. If they do not settle at this position, adjustment is made by turning the rheostat screw #3 in the corresponding analyzer cell. After testing, the bronze filter wool and covers should be replaced.

Check mechanical zero and current adjustment as previously noted after which, with the engine running, the mixture ratio will immediately be shown on the indicator. It is recommended that the engines be run at least 1300 r.p.m. to obtain a good sample of gas.

d. Maintenance

The bronze filter wool in the analyzer cell will collect oil and particles of carbon and should be examined occasionally; and when necessary, the wool removed and washed first in gasoline and then in water. Shake out the water before replacing. If old wool is corroded, use new wool.

To compensate for the water vapor present in the sample of exhaust gas, a water compensator or wetted wick is fitted in the air side of the analyzer cell. This wick slowly dries out and at long intervals, say 3 or 4 months, the water requires replenishing. To do this, remove the large black hexagonal screw #6 which contains the wick, from the front of the analyzer cell. The wick should be wetted with clean water and the surplus shaken off after which it should be replaced. Whenever this wick is wetted the electrical zero should be checked in accordance with paragraph C.

To obtain a good exhaust sample move curved tube in and out of exhaust pipe while engine is running. Connect one end of a $\frac{1}{2}$" I.D. rubber hose to drain line from analyzer cell and immerse free end in an open bottle of water; best sample is being obtained when water bubbles rapidly. Be sure curved tube is pointed in towards the flow of exhaust gas.

4. Operation

The use of the Cambridge Indicators is detailed in paragraph M, Section II-A of this manual and in the Pilot's Manual. Full details on the construction of the instrument and the theory of its operation are obtainable from the Cambridge Instrument Company, Ossining, New York, or by communicating with the Service Department of the Wright Aeronautical Corporation.

K. Curtiss Constant Speed Propeller

1. General

The propellers installed on these airplanes are of the 3-blade, constant-speed, electrically-operated, full-feathering type. These units are manufactured by the Propeller Division of the Curtiss-Wright Corporation, Buffalo, New York.

The model designation is C-532 DRH. The blade designations are shown in Curtiss drawing No. 89305-18. An explanation of these numbers is given in the Curtiss Propeller Manual which accompanies each airplane. Blade replacements are ordered by reference to the basic drawing number only, the serial number being disregarded. Complete blade assemblies including the Duplex ground angular contact bearings must be ordered if replacements become necessary.

Each propeller installation consists mainly of a three-bladed aluminum alloy propeller and steel hub assembly which is mounted on the engine, together with an electric power control unit; a slip-ring and brush assembly located aft of the hub on the power unit and the engine respectively; a propeller governor assembly located on the front wing spar in the engine nacelle; and the necessary electric and manual controls, wiring, and cables. A detailed description of these units and their operation is contained in the Installation and Maintenance Instruction Book for Curtiss Propellers which accompanies each airplane.

2. Controls

The pilot's controls consist of a group of electric switches and two manual control wheels for setting the propeller governors. These controls are installed in the left side of the fuselage in the cockpit as shown in Figure 4. There are three switch assemblies for each propeller as follows: (See Simplified Wiring Diagram, Figure 67.)

a. Control Switch

One switch is provided for each propeller and is installed on the longeron at the pilot's left side. A shield is provided over the switch handles to prevent inadvertant operation.

This switch is a safety snap switch, GE Type GB-130, equipped with a thermal overload relay which automatically breaks the circuit after a predetermined period of overload. The overload relay is capable of closing the circuit automatically after it has cooled sufficiently, thus compensating for the normal fusing of the circuit. The switch is used to shut off the power supply to the propeller circuit when the airplane is not in use, thereby preventing a steady drain on the battery.

b. Constant Speed - Manual Control Selector Switch

One switch is provided for each propeller and is installed on the longeron immediately forward of the control switch. This switch is a standard type B-9 two-position snap switch. It is used to switch the source of power supply into either the manual-control circuit or the constant-speed control circuit.

c. Manual Control Switch

One switch is provided for each propeller and is located on the longeron immediately forward of the constant speed-manual selector switch. This switch is a standard type B-11 momentary contact switch having two poles and an intermediate "Off" position. This switch must be held in either the "increase" or "decrease" contact position to operate. Manual control of the propeller blade angle is obtained by this switch which shunts the source of power supply to "increase pitch" or "decrease pitch" as desired.

3. Propeller Governor and Relay

The constant speed of the engines is maintained by the propeller governor which is driven by a flexible drive shaft connected to an adapter installed on the engine oil pump. The speed of the governor is dependent upon the speed of the engine, which in turn is governed by the pitch of the propeller. The speed at which the governor is set by means of the control wheel in the cockpit is held constant by an integral spring-loaded flyweight in the governor mechanism. The spring and flyweight forces oppose each other, jointly controlling the position of a contact-operating rod which in turn operates a spring-loaded movable contact point that travels between two fixed contact points in the governor mechanism. When flyweight forces overbalance the spring load, contact is made with the governor switch fixed contact point, closing the "increase pitch" circuit; and when the spring load overbalances the flyweight centrifugal force is made on the opposite fixed contact point, closing the "decrease pitch" circuit.

The current from the governor is transmitted to one of two magnetic coils in a switch relay which is provided between the governor and the propeller motor. These coils may also be energized by the manual control selector switch.

When the coil on one side of the switch arm is energized by either the governor or the manual selector switch, the switch arm in the relay leaves its normal position and closes the propeller circuit which flows through the switch arm and through the fixed contact to the electric motor on the nose of the propeller. The two fixed contacts of the relay are connected to oppositely-wound fields of the electric motor, thus controlling the direction of rotation of the motor depending upon the displacement of the switch arm.

A change in the governor setting for either propeller can be made through a range of 20° starting from 20° low pitch and stopping at 40° high pitch. This change in setting is effected by moving the micarta control wheels in the cockpit. Full "feathering" of the propellers to an angle of 88.6° is also obtainable by operating the selector switch and the momentary switch to "Increase" the pitch. (See Operating Instructions, Paragraph P, Section II-A.) A name plate on the wheel bracket indicates "Increase" and "Decrease" pitch and maximum engine R.P.M.

4. Installation

a. Propeller Governor

Since all airplanes are not flight tested before delivery, it will be necessary to check and adjust the setting of the propeller governors with the cockpit indicators on each airplane. The actual test is made during flight when the engine is permitted to turn up the maximum R.P.M. for a longer period. The general directions for installing the controls are as follows:

After connecting the propeller governor flexible drive shaft between the governor and the oil pump adapter, rotate the sprocket on the governor to the left (or counter-clockwise) the full limit. Turn the control wheel in the cockpit to full "Decrease" position. Install the chain segment of the LEFT HAND control cable on the sprocket leaving two links of the chain on the "Decrease" side of the cable at the top of the sprocket. For the RIGHT HAND control cable the same instructions apply except that the short side of the chain is at the bottom of the sprocket. Connect the turnbuckles in the cockpit and remove the slack in the system.

Rotate the sprocket at the governor to the right (clockwise) until the "witness" or "reference" marks placed on the sprocket and the housing coincide. In this condition the governor is set to maintain a propeller speed of 2200 R.P.M. The name-plate in the cockpit may then be moved to coincide with the position of the indicators. In event the pointers do not line up, the cable lengths may be changed at the indicator assembly. Final adjustments are made with the turnbuckle. Three positions for the cable anchor-eye are provided.

A full power flight check of the installation should be made when practicable by adjusting the propeller governor while watching the tachometers until the engines are automatically held at 2200 R.P.M. This speed should be held only long enough to adjust the governor setting; then reduce the engine speed by backing off the throttle and land the airplane. It is not necessary to change the governor setting to land, since the blades are already in the "low pitch" (landing) position. The name-plate in the cockpit can then be moved to coincide with the position of the pointers, and the cable stops then moved up to limit cable travel beyond this point.

b. Propeller Installation

Important: Before installing or removing a propeller, release the latches which secure the cap assembly onto the brush housing and pull the brushes out of the housing.

Remove the four screws in face of power unit cover and remove the cover.

Remove the six studs in the face of plate at front of power gear assembly and take the power unit from the hub.

Place the propeller on the engine shaft, aligning the splines to match, rotate the blades to the proper direction, and align the marks on the blade gear with the marks inside the hub and push the propeller in place by hand.

Tighten the crankshaft nut by hand as far as possible; then insert a bar approximately 6 feet long and one inch in diameter through the holes in the cap and tighten fully, being careful not to strain the nut excessively and pull it out-of-round.

Fit the locking tube to the adapter so that the clevis pin holes line up with the holes in the crank-shaft nut. Insert the clevis pin in place (head toward center) and lock it with a cotter pin.

Replace the power unit and cover, securing the studs and screws with lockwire, first making sure that the two 20° reference marks line up.

Replace the brush assembly in the housing. Further details on the assembly and maintenance of the propellers and controls are contained in the Curtiss Installation and Maintenance Manual. For operating instructions see paragraph P, Section II-A.

L. Starting System

The starting system of this airplane is operated either electrically or manually; normal starting being accomplished by means of two Eclipse M-2609 starter switches mounted on the right side of the pilot's instrument panel. The starters are Eclipse Series 11 Inertia Type units mounted on the supercharger housing rear cover. A complete description of these units is given in the Eclipse Instruction Book which is included with the Miscellaneous Accessory Bulletins.

In general, the electrical use of the starters is accomplished by pushing in on the switch control handles on the pilot's panel to supply current through the Eclipse M-2101 Starter Relays located in nacelles junction boxes, and thence to the starter. The starter switch should be held in this position for about 20 seconds to allow the starter motor to obtain maximum speed. The handle is then pulled outward from the panel causing current to flow to the Eclipse M-2400-A-1 Meshing Solenoid on the starter which engages the starter with the engine. A Delco-Eclipse AV-1101 Booster Coil provided in each starter wiring system furnishes supplemental ignition sparks simultaneously with the engagement of the starter clutch. The electrical circuit for this system is shown in the Wiring Diagram, Figure 67.

Warning. Start only one engine at a time. If both switches are operated at the same time, the circuit will be overloaded and the 30-ampere fuse that protects the system will be blown out. When starting engines that have been idle overnight and at any time during extreme cold weather, the engines should be turned over at least four revolutions by hand before engaging the starter.

In extreme cold weather it is advisable to use the hand-crank, or a portable external Electric Starter attached to the manual cranking shaft, for turning up the inertia system. This will insure against running the airplane battery down by repeated unsuccessful attempts at starting.

Note: The Portable External Electric Starter may be purchased from the Eclipse Aviation Corp., East Orange, New Jersey.

For manual operation of the starter, a hand-crank is supplied and is always carried inside the rear section of the nacelle in the wheel well. When using the hand-crank, the starter inertia flywheel is brought up to speed and the mechanic given time to withdraw the crank before engaging the meshing solenoid from the cockpit.

Complete instructions on the operation of the starter is given in the Pilot's Instructions, Section II-A.

M. Power Plant Maintenance

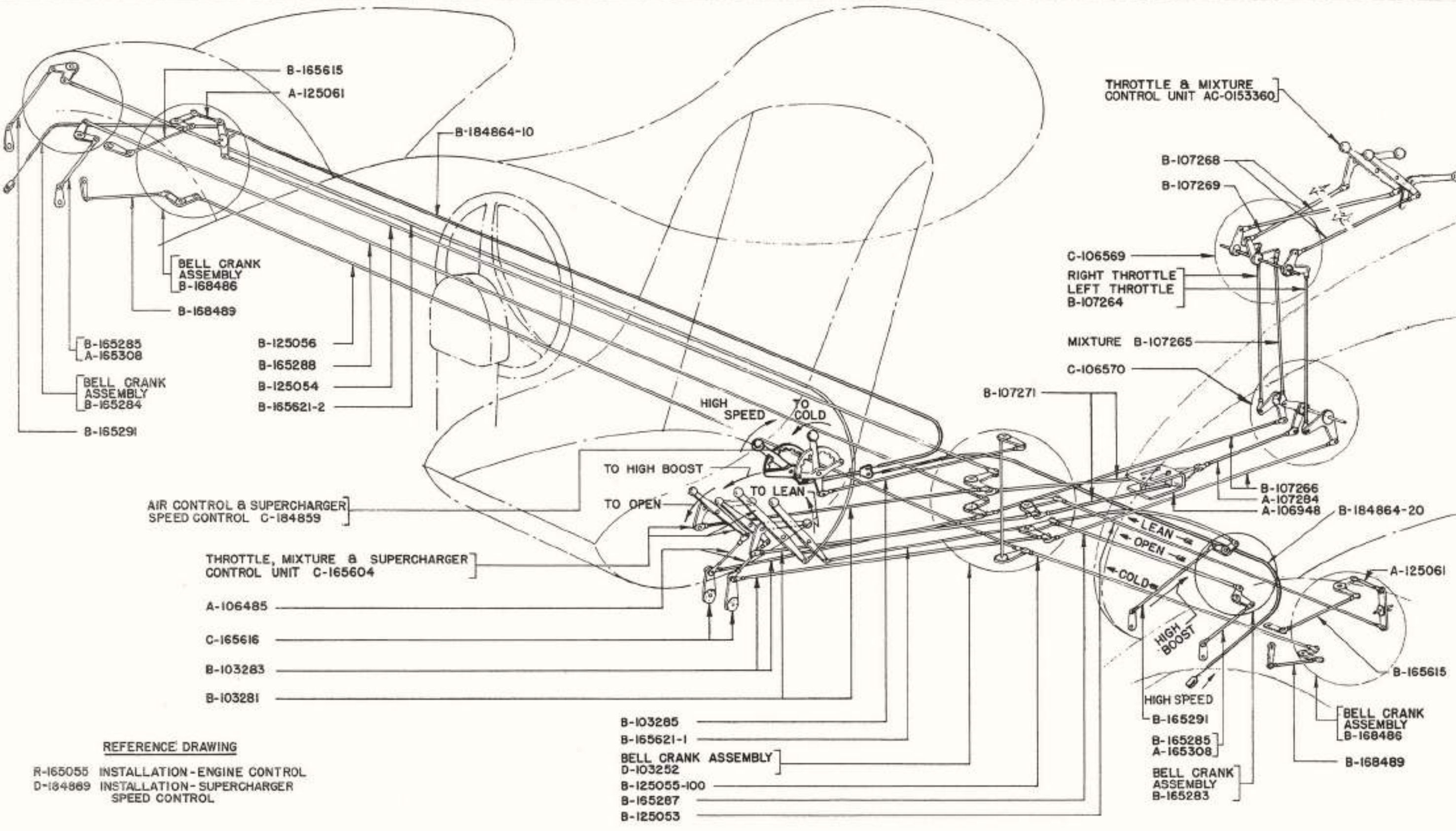
Complete instructions for the engines and accessories are contained in the publications mentioned in the preceding paragraphs and in Appendix II of this Maintenance Manual. The periodic inspection procedure is detailed in Section XXIII.

Lubricants for the engine, propellers and accessories are listed in Appendix IV of this Manual or in the handbooks and bulletins covering the accessories. Spark plugs should be coated with "No-ox-Id" Grade D, which is applied with a camels hair brush. This compound is manufactured by the Dearborn Chemical Co., 310 South Michigan Ave., Chicago, Illinois. The coating should be put on before installing the plugs and when they are stored.

It has been found the moisture condenses inside the plugs when they stand idle for lengthy periods particularly, in tropical climates. When this happens, the plugs will not function properly until they are taken apart and dried out in an oven. It is advisable to store spark plugs in air-tight containers to eliminate this trouble.

The above conditions of moisture condensation applies to other parts of the engine equipment such as magnetos, voltage control panels, pumps, etc. Moisture-proof storage of engine and airplane accessories is desirable as far as possible.

Periodic checks should be made of the engine and accessory installation to ascertain the security and proper functioning. Detail information is supplied in the Wright Instruction Manual and in the Miscellaneous Bulletins furnished with each airplane.



REFERENCE DRAWING

R-165055 INSTALLATION-ENGINE CONTROL
D-184869 INSTALLATION-SUPERCHARGER SPEED CONTROL

S.A.W. & H.G.N.
12-22-37

FIGURE 40 MODEL 139-WH3 ENGINE CONTROL DIAGRAM

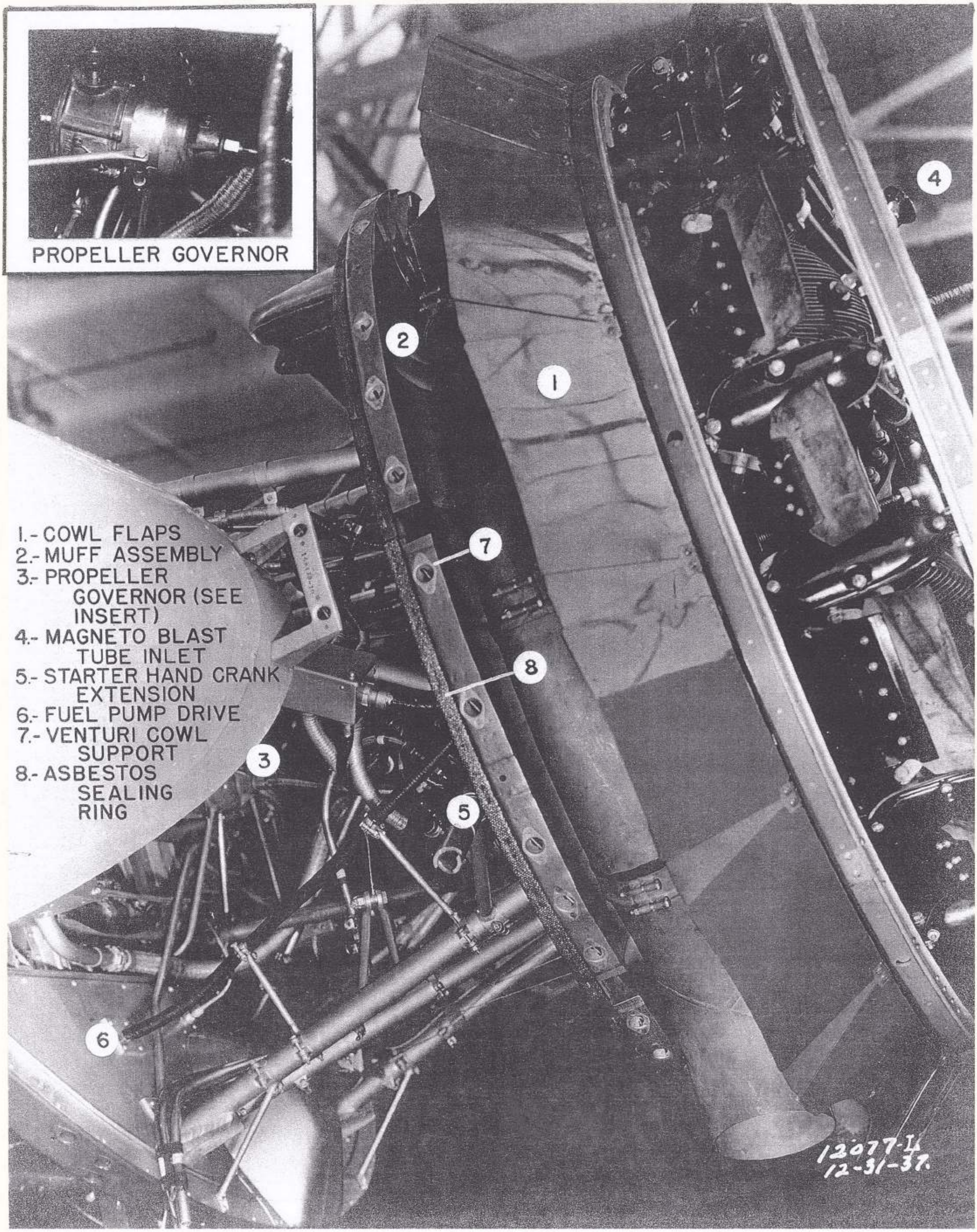


FIGURE 41 RIGHT ENGINE INSTALLATION - RIGHT SIDE VIEW SHOWN A

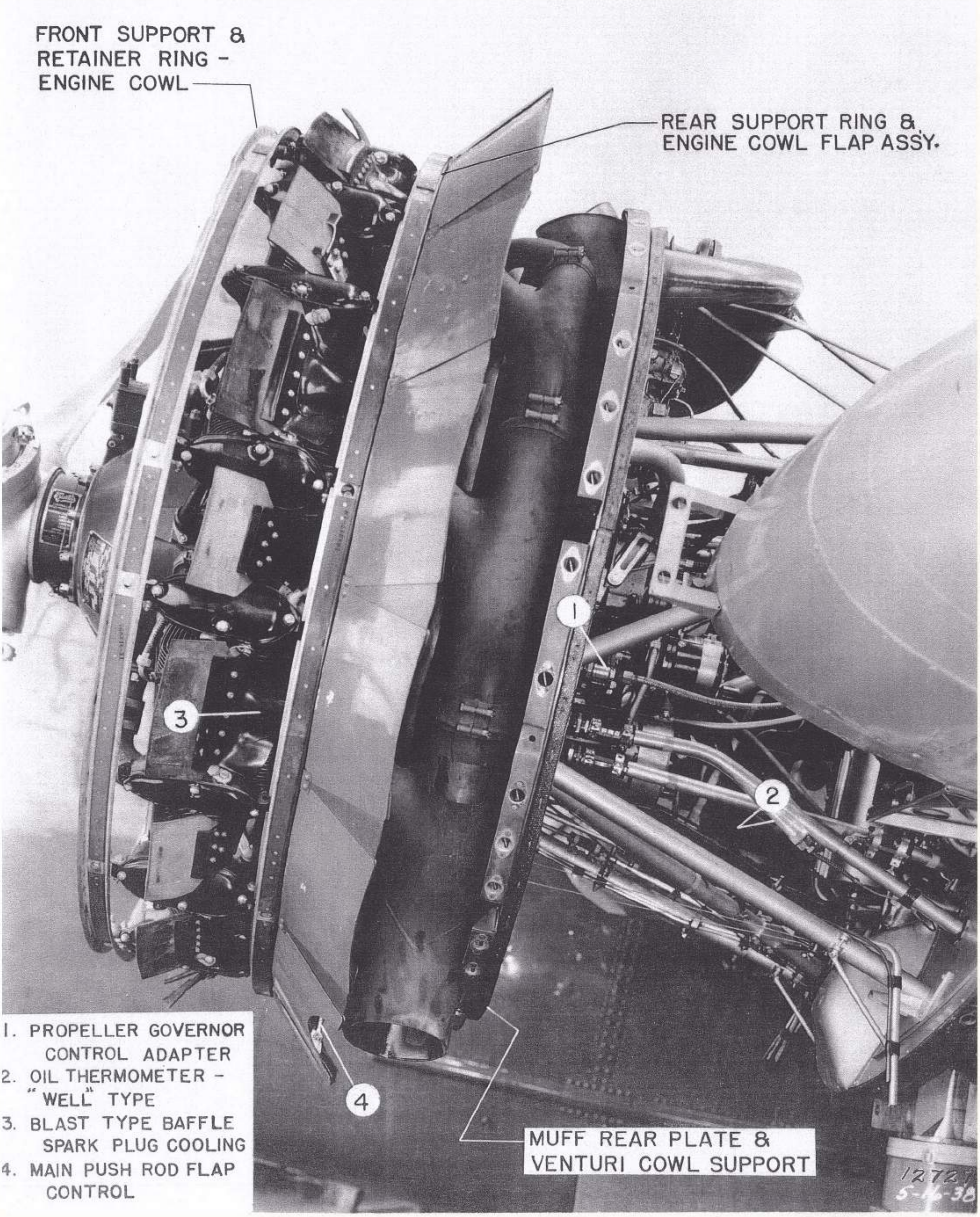


FIGURE 42 LEFT ENGINE INSTALLATION - LEFT SIDE

C

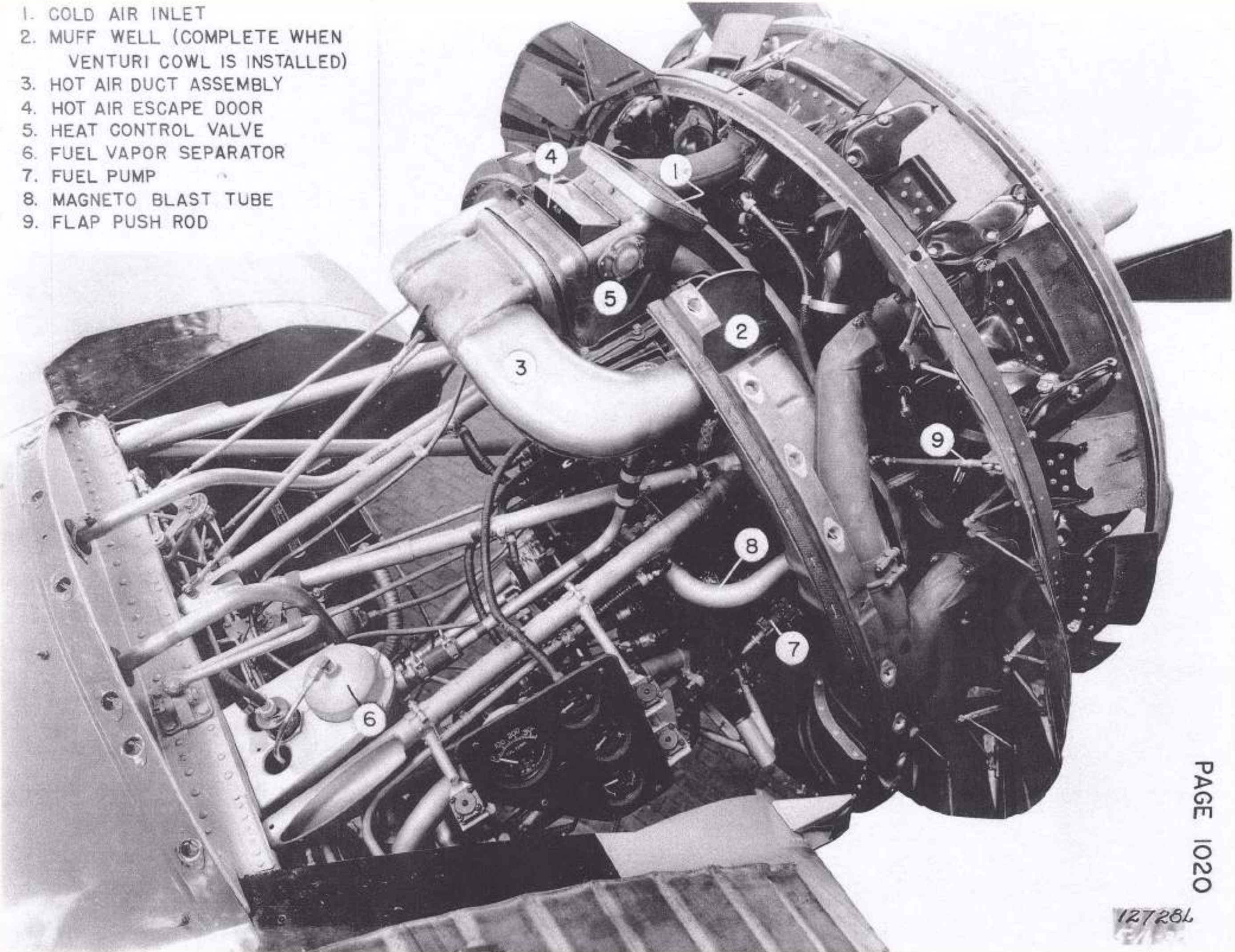


FIGURE 43 LEFT ENGINE INSTALLATION - TOP VIEW

SECTION XI

FUEL SYSTEM

A. Description

The fuel system diagram is shown in Fig. 46. A small diagram of the fuel system is tached to the side of the fuselage in the pilot's cockpit above the fuel cock controls.

Four fuel valve controls, shown in Fig. 4, are located at the left side of the pilot cockpit in a position convenient for operation. The controls are identified by their name plates. The fuel tank valves Nos. 1 and 2 are located in the bomb bay on the left side are operated by their respective control handles through two bevel gear units and a torque shaft. The engine selector and the cross-feed valves (Nos. 3 and 4) are located below the valve control panel. Referring to Fig. 46, it should be noted that the reserve fuel supply is contained in the left main tank, and when the gauge indicates about 40 gallons (151 liters) in this tank, valve No. 1 must be turned to another tank unless all other tanks **empty**; if so, it should be turned to "Reserve On." Valve No. 2 is the auxiliary valve, when using the auxiliary fuel from either rear tank, or bomb bay tank, valve No. 1 (the main tank valve) must be set to "auxiliary" position. Control valve No. 3 is the engine selector valve, with which the fuel supply to either or both engines may be shut off. No ly this valve will be on "Both On." In case of fire in one nacelle the fuel to that engine should be turned "Off." If either engine pump fails, the fuel valve No. 4, which is a cross-feed shut-off valve that is normally off, should be turned to "On," thereby supplying both engines from the one remaining pump. The cross-feed valve should be "On" during all take-offs and landings, but should be turned "Off" after a safe altitude is reached, in order that a failure of either fuel pump may be detected.

A pump handle is located forward on the valve panel and is used to operate the Type D-6 combination Hand Pump, Strainer and Bypass and Relief Valve which is located on the left side below the valves. This fuel unit has a capacity of 425 gallons (1608 li.) per hour which is ample to maintain fuel pressure if an engine driven pump should fail. If the hand (wobble) pump is used in lieu of the single engine driven pump, the cross feed valve should be turned "OFF" and the engine selector valve should be left at "BOTH ON."

The relief valve is constructed with an integral check valve which permits the engine driven pump to draw fuel through the strainer and around the Hand pump, thus eliminating the pressure drop through the hand pump valves.

The strainer screen is easily removed for cleaning. The pump cover is doweled to prevent misalignment of the rotor in reassembling the pump if it has been taken apart. The relief valve is not adjustable. It is set to maintain fuel line pressure of 8 lbs./sq. in (3.62 kg./sq.cm.) to take care of line drop to the carburetor.

A drain cock is provided in the bottom of this fuel unit for cleaning out residue, into a funnel below, which empties overboard through the side of the fuselage.

Two Pesco (Pump Engineering Service Company) engine driven fuel pumps, each having a capacity of approximately 325 gallons (1230 liters) per hour, are used to pump the fuel from the tanks, through two vapor separators in the lines, to the engines. The pumps are located behind the firewall, below the lower surface of the wing, and are remotely driven by the engines by means of 90° bevel gears and flexible shafts. Each pump is provided with a sylphon-type pressure relief valve mounted on the pump body. The pressure of the flow of fuel to the carburetor is governed by this valve which can be adjusted by means of the knurled nut located on the valve housing. The pressure is increased by screwing the nut down, or counter-clockwise.

Each engine should be adjusted separately under the following conditions:

1. Engine selector valve set to correspond to the fuel relief valve being adjusted.
2. Cross feed valve "OFF."
3. Operate engine at 1800-2000 r.p.m. Do not run longer than $1\frac{1}{2}$ munutes at this speed. Keep the landing wheels securely blocked during this check. As a further precaution lash down the tail.
4. A pressure of 3 to 4 lbs. per sq. in. (.21 to .28 kg./sq. cm.) should be maintained.

Because changes in altitude cause extreme changes in fuel temperature, the fuel becomes saturated with non-combustible gases and vapors which affect engine operation. To reduce the presence of these particles,a centrifuge type vapor separator is provided between the carburetor and the fuel pump for each engine. These units are installed on the front spar in the nacelle as shown on the Supplement Fuel System Drawing of the Vapor Separator Installation.

The vapor separator consists of a small tank assembly into which the fuel is pumped through an offset intake port near the center. The fuel is forced in a centrifugal motion through the tank leaving it at the bottom through an outlet port connected to the carburetor. The whirling movement of fuel in the tank causes the air and vapors to separate from the fuel. The vapors rise to the top of the tank passing through a perforated diaphragm which aids in separating the vapors from the liquid fuel. The vapors escape under pressure through a small diameter orifice provided in the top of the tank cover, and are carried in a $\frac{1}{4}$ O.D. x .032 copper tube, and pipe "Tee" connector, common to both separators, to the vent line connection of the Left Main fuel tank. Since approximately 3.00 gallons (11.34 li.) of liquid fuel are returned each hour from the separators through the vent line, the Left Main tank will overflow if full,unless fuel is used from this tank first. Fuel is returned to this tank from the separators in order to maintain the reserve supply in one tank until all fuel is consumed.

It should not be necessary to disassemble the vapor separators since there are no moving parts to get out of order. The tank can be drained by removing the plug provided in the bottom. The vent lines may be flushed out by disconnecting at the main tank vent and removing the plug from the base of the separator tank, then pump fuel or air through the lines.

A fuel pressure warning unit is provided for each engine to warn the pilot of a drop in fuel pressure below a safe operating point of 2-3/4 lbs./sq. in. (1.25 kg./sq. cm.). The warning signals consist of two red lamps located on the auxiliary instrument panel beside the fuel gauge. The lamp circuits are energized by the ignition switch.

The warning unit is installed on the bracket which supports the vapor separator. See Figure 43A. A 1/4 inch fuel line is connected between the bottom of the vapor separator, and the warning unit as shown in Figure 46.

Maintenance and adjustment of the fuel warning unit are described on the Pioneer Instruction sheet for this accessory. See list of Accessory Bulletins in Appendix II.

B. Fuel Tanks - Wings

The normal fuel load is carried in four tanks installed in the wing center sec tion. The total fuel capacity of these tanks is 516 gallons (1953 liters). The le and right forward tanks are designated Main Tanks, and have a capacity of 113 gallo (428 liters) each. A reserve supply of 40 gallons (151 liters) is carried in the left front tank and is sufficient for approximately 20 minutes flight. The rear wi tanks are designated Auxiliary Tanks, and have a capacity of 145 gallons (549 liter each. The fuel from any tank can be selected and shunted to either engine through the tank and engine selector valves. See Figure 46.

The fuel tanks are strapped in padded cradles permanently constructed into the top of the wings, the straps passing under the tanks and being joined with turnbuckles. The installations in the right wing are shown in Figure 47.

The tanks are of Martin Type riveted construction, made of aluminum alloy with baffles provided to decrease the surge of fuel. The baffles and end plates are riveted to the shell with a special sealing compound between the faying surfaces.

A detachable sump is provided in the bottom of each tank at the low side when the airplane is resting on the ground. The shape of the tank is such that the sump will also be at the low side in level flight. Drain cocks are provided in the bottom of each sump so that accumulated dirt and water can be drained off. These drains are reached through an access hole provided in the lower wing skin below eac unit. When draining sediment from the tanks, the one-inch plug of the drain cock may be unscrewed from the tank to remove large particles that may have entered through the filler unit. For daily draining of water, the drain cock is used without removing the plug. A coarse mesh strainer is provided in each tank outlet line and these may be removed by taking out the screws that secure the flanged fitting to the tank sump. Be sure that these fittings are properly secured with safety wire when they are replaced and closed. Each tank is vented to the outboard end of the tank, and then aft to the rear wing spar, and drains below the wing. The vent line is formed with a "goose neck" which prevents fuel from flowing out during maneuvers. (See Figure 46.)

An electric type Liquidometer Fuel Gauge is used in each tank with an indicator gauge installed in the pilot's cockpit. This system is equipped with a voltage compensator, stroke adjustment box, electrical leads, and a five-point selector switch which is located in the cockpit. The indicator gives a reading for the amount of fuel in any one of the four wing tanks and the auxiliary bomb bay tank when used. The indicator readings in each case must be converted in accordance with the conversion chart mounted on the fuel quantity panel. Adjustment of this system is described in Paragraph H.

C. Removal of Wing Tanks

Should it be necessary to remove a fuel tank, the procedure is as follows:

1. Jack up the engine so as to take most of the weight of the engine off the mount. The reason for this is that the holes for the screws securing the tank cover to the wing were drilled without the engine in place; and when the engine is mountec and the tank cover removed the center section deforms slightly, throwing the holes i the cover out of place. Since the tank door forms a part of the wing structure, the unsupported weight of the engine should not be allowed to be taken by the wing when the covers are off.

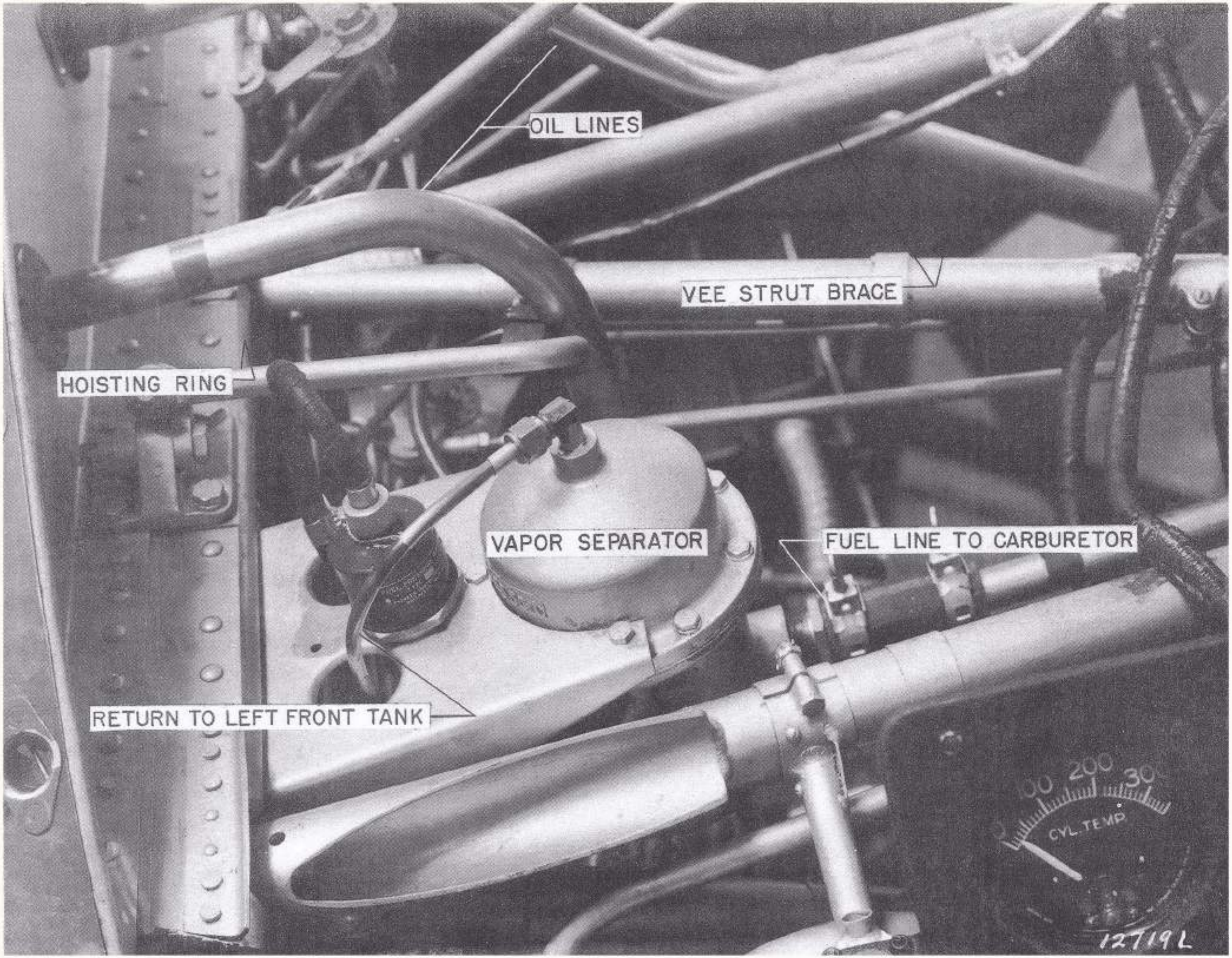


FIGURE 44 INSTALLATION FUEL UNITS - LEFT HAND ENGINE

2. Remove tank doors.

3. Disconnect vent line fittings at filler cap. Disconnect liquidometer gauge unit at the tank and also the fuel lines at the sump and in the fuselage. Disconnect bonding connections.

4. Open the straps and loosen the end brackets.

Care in cleaning fuel tanks and the fuel system is particularly necessary since a formation of aluminum hydroxide may occur upon condensation of atmospheric moisture in the tanks. Special care should be taken in cleaning tanks withdrawn from storage. All strainers should be cleaned as often as necessary as indicated in service, and the fuel lines should be flushed by permitting a small amount of fuel to flow through them

NOTE: The four fuel tanks have riveted seams that are filled with a sealing compound. Due to this construction, these tanks should not be cleaned with steam as this will loosen the sealing compound and may cause the tanks to leak.

D. Auxiliary Bomb Bay Tanks

Provisions are made in the bomb bay for the installation of either a 356-gallon (1347 liters) fuel tank or a 250-gallon (946 liters) tank. Installation equipment is provided for only one type tank as required. The 356-gallon tank is rigidly supported in the bomb bay so that the cradles must be disassembled to remove it. The 250-gallon tank is hung on the bomb racks and can be dropped from the airplane in an emergency.

If the auxiliary fuel tank is to be installed in the bomb bay, it is necessary to remove the front pulley hanger extending across the top of the bomb bay. The hanger is supported at the center by a yoke which is inserted through the corrugations at the top of the bomb bay and bolted to the structure channel provided. It is necessary to remove the pilot's seat to accomplish this operation. The ends of the hanger are bolted to the two side pulley brackets above each bomb rack. These end brackets are not removed.

E. 356-Gallon Tank (Optional Special Equipment)

1. Description

The 356-gallon Bomb Bay Auxiliary Fuel Tank is equipped with a fuel dump valve located in the bottom rear of the tank. Fuel can be dumped from the tank in an emergency by pulling on the Emergency Bomb Release cable which is extended through the bomb bay and connected to the dump valve releasing cam. (See Figure 49A.)

The valve mechanism operates internally into the tank, being lifted by the cam at the bottom. When operated, the cam is rotated until the radius end snaps into a groove machined in the surface of the valve, thus locking it open. The additional leg provided on the cam stops against the valve seat to limit the rotation of the cam and to keep the valve fully open.

The dump valve mechanism consists of a spring-loaded valve which is supported inside the tank by a cast aluminum hanger. A fiber bushing suspended in the top of the hanger provides a bearing for the valve stem and also serves to maintain the spring in position. The fuel retaining valve is fitted with a synthetic rubber seal recessed into the periphery of the seat and cemented with Thiokol No. G-18 synthetic rubber cement. This cement is manufactured by the Thiokol Corporation, Yardville, New Jersey.

The dump outlet is provided with a flanged cast aluminum valve seat to which the legs of the hanger are secured with fillister-head screws and fiber locking nuts. A Vellumoid gasket with a diameter equal to the valve seat flange is provided between the hanger and the flange. The valve and spring are assembled with the hanger before the hanger is bolted to the flange. Bakelite Varnish is used when installing the Vellumoid gasket with the valve assembly in the tank. The assembly is secured in place with fillister-head screws which are safetied with lockwire.

2. Installation of 356-Gallon Bomb Bay Tank

a. Before proceeding with the installation make sure that the supporting brackets are bolted in place on the front and rear spars. Install the front and rear tank strap hangers on the brackets located on the sides of the fuselage above the longerons. See the Installation Drawing for the 356-Gallon Tank.

b. Hoist the tail so that the airplane is approximately level. Open the bomb doors as far as possible, slide the tank under the airplane, and turn it to an upright position. Before hoisting the tank into place, plug in the Liquidometer gauge cable, turn the selector switch in the cockpit to "Bomb Bay" and check the indicator gauge dial. If it does not read "Empty" when the gauge float is in the bottom of the tank, remove the cover from the Liquidometer stroke adjustment box located on the left side of the airplane at the forward end of the bomb bay and adjust the pointer travel by turning the screw marked "7" on the R+ side either to the right or left until the pointer indicates "Empty." If sufficient adjustment cannot be obtained in this manner, it will be necessary to remove the cover from the unit on top of the tank, loosen the rheostat position clamps, and turn the rheostat in the required direction. Tighten the clamps when the correct position has been established. Note: This should be done whenever the tank is installed.

c. Lift the tank into position. Make sure that the felt pads are in the proper position. See that the filler and vent line hose connections located on top of the wing behind the pilot's seat slide together properly. Assemble the two tanks straps under the tank. Install the fuel line from the tank sump to the rear fuel valve in the left side of the bomb bay compartment.

d. Install the rubber apron as shown in Fig. 49A. This apron protects the radio operator and rear gunner from the spray thrown back as the fuel is dumped in an emergency.

e. Attach the dump valve release cable to the dump valve fitting. See the Installation Drawing.

f. When filling the tank, do not insert the filling hose nozzle more than approximately two inches into the filler line. There is a sharp bend in the line just below the top and spillage occurs if the nozzle is pushed down to this point.

When removing the bomb bay fuel tank the Liquidometer gauge electric cable must be taped to the conduit leading into the Type A-3 light located in the upper rear left side of the bomb bay. Remove the tank support straps and replace the access doors in the cover over the cable turnbuckles at the rear right side of the fuselage.

The following wording appears on an instruction plate located on the front bulkhead in the bomb bay to the left of the bomb door retracting screw if the 356-gallon auxiliary fuel tank is provided for.

"Warning: When removing the bomb bay tank, disconnect the dump valve cable at the link near the tank sump and pull the cable through the frame. Insert cable under spring clip located on other side of this frame and name plate. Pull the emergency bomb release to check that cable does not prevent its operation before installing bombs."

F. 250-Gallon Tank (Optional Special Equipment)

This auxiliary fuel tank is installed in the bomb bay between two end braces similar to those used for the 356-gallon tank. The bottom support consists of a wide two-piece padded cradle strap which is bolted together along the bottom center of the tank. The outer ends of the strap cradle are attached to a Bomb Release Shackle installed on station No. 2 on the right-hand rack and station No. 3 on the left-hand rack. The bomb rack emergency release controls are used to drop this tank from the airplane if necessary. A description of the emergency release system is given in paragraph G-2, Section XV.

The fuel supply line from the tank sump is equipped with a special releasable union which permits dropping the fuel tank without destruction to the entire fuel line. This unit is shown in the insert, Figure 49B. After the fuel tank has been installed, the fuel supply line is connected at the union by inserting the lower fitting into the upper, then moving the saddle support bracket in place where it is secured by turning the knurled nut down against the washer beneath it. The two cams provided (on the legs of the support saddle) seat in grooves machined in the bottom surface of the washer thus locking the saddle against the union when the nut is turned down. Continued turning of the nut draws the lower half of the union up against a rubber seat and seals the joint against leakage. The nut and washer are locked together with safety wire which should be removed and the nut backed off when the tank is taken out of the airplane.

The support saddle assembly is equipped with a yoke to which the union-releasing cable is connected and attached to a free sliding link installed on the bomb door split nut closing cable (See Figure 65). If these cables are replaced, care must be taken to provide the proper lengths, and to set the clamps on the cables so that the emergency release system will function properly as follows:

1. Initial pull of pilot's or radio operator's emergency release handle opens bomb doors.

2. Continued pull releases union in fuel line.

3. Final pull trips bomb racks and drops fuel tank.

To accomplish this the split nut closing cable is equipped in the bomb bay with two clamps installed on the cable approximately 13 inches apart. A light tension spring is installed between the clamps drawing them together and putting slack in the cable. The loose link provided for attaching the cable to the union release yoke is installed on the nut closing cable forward of the front spring clamp. This clamp must be located so that the union support saddle will be tripped immediately after the bomb doors are opened. Enough slack is left between the clamps to permit the continued pull on the emergency release controls and the subsequent tripping of the bomb shackles.

G. Installation of the 250-Gallon Tank

1. Before proceeding with the installation make sure that the supporting brackets are bolted in place on the front and rear spars. These brackets are removable and are sometimes taken out when the airplane is used for bombing missions.

2. See that the fuel line from the valve to the releasable union is intact and that the releasable union is assembled in accordance with the instructions given on the metal warning plate installed near the union.

3. Latch each half of the tank strap to the rear hook of a bomb shackle.

4. Cock station 3 on the left hand bomb rack and station 2 on the right hand rack.

5. Attach the shackles to the cocked stations on the racks. (Hook the short strap to the right-hand rack.)

6. Check the rlease mechanism by slowly pulling the emergency release in the pilot's cockpit. The system should function according to the following schedule:

a. Bomb bay doors drop open.

b. The releasable fuel line union opens.

c. The tank straps drop from the shackles.

If the above order is not obtained, adjust the position of the latch arm that operates the union by moving the clamp block on the release cable.

7. Hoist the tail of the airplane to an approximately level position. With the bomb bay doors open as far as possible, slide the tank under the airplane and turn it to an upright position. Before hoisting the tank into place, plug in the Liquidometer gauge cable, turn the selector switch in the cockpit to "Bomb Bay" and check the indicator gauge dial. If it does not read "Empty" when the gauge float is in the bottom of the tank, remove the cover from the Liquidometer stroke adjustment box located on the left side of the airplane at the forward end of the bomb bay and adjust the pointer travel by turning the screw marked "7" on the R+ side either to the right or left until the pointer indicates "Empty." If sufficient adjustment cannot be obtained in this manner, it will be necessary to remove the cover from the unit on top of the tank, loosen the rheostat position clamps, and turn the rheostat in the required direction. Tighten clamps when correct position has been established. Note: This should be done whenever the tank is installed.

8. Lift the tank into position. Make sure that the felt pads are in the proper position. See that the filler and vent line hose connections located on top of the wing behind the pilot's seat slide together properly. Important: Do not install a hose clamp on the lower side of these connections. Assemble the two halves of the supporting strap under the tank (Refer to G.L.M. Installation Drawing of the 250-Gallon Tank). Install the fuel line from the tank sump to the releasable union.

9. The tank installation is now complete and the tank may be filled. Do not insert the filling hose nozzle more than approximately two inches into the filler line. There is a sharp bend in the line just below the top and spillage occurs if the nozzle is pushed down to this point.

H. Adjustment of Wing Tank Liquidometer Unit

When installing a new wing tank or a new gauge unit in a wing tank, proceed as follows:

1. Place gasket on tank flange.

2. Insert a looped string through the eye in the flat arm and out through the opening provided in the top of the tank, so that the float can be moved up and down when setting the stroke (See Figure 45).

3. Slip the float through the tank opening and fasten down the tank unit with five special screws and copper asbestos gaskets as shown on Fig. 45. These screws must be drawn up tight before locking.

4. Move the float up and down by pulling and releasing the stroke setting string. If the rheostat shoe does not stop at equal distances from the ends of the rheostat winding, loosen the rheostat position clamps (See Fig. 45) and turn rheostat assembly in required direction. Tighten clamps when correct position has been established.

5. Figure 45 pertains to the adjustment of the Liquidometer Electric Tank Quantity Gauge only and should not be confused with the Liquidometer Stroke Adjustment Box which is used for calibrating the various tank units. The method for calibration is outlined in the following paragraphs:

a. The Stroke Adjustment Box is located in the left side of the airplane at the forward end of the bomb bay and is connected to the Tank Gauge by means of the electric cable shown in Figure 45. The electrical connections at the opposite end of the cable are shown on the left side of the Simplified Wiring Diagram (Figure 67) and indicated by the sub-title "Tank Units, Fuel Quantity."

b. After making the adjustments described in paragraphs 1 through 4, complete the electrical connections as shown in Figure 45.

c. Turn the cockpit selector switch to indicate the tank unit being installed and check the movement of the gauge pointer when the tank float is resting on the bottom. If the indicator does not read "Empty", turn the proper adjusting screw in the "Stroke Adjusting Box" marked with the corresponding tank number (on the "R+" side of the terminal block) in either direction until the gauge reads "Empty." The fuel tank numbers are shown in Figure 48, indicated as numbers 1, 2, 3, 4 and 7. The terminals in the Stroke Adjustment Box marked number 5 and number 6 are not used. The tank float must rest in a horizontal position on the tank bottom to make the foregoing adjustment. Repeat the operation with the float drawn to the top of the tank by the stroke setting string (Fig. 45), indicating the "Full" position. In this case adjust the screw on the "R-" side of the block.

Caution: When pulling the float to the top of the tank with the stroke-setting string, do it gently so as not to spring the float arm. Bear in mind that it is the fuel that will support the float when the gauge is in service.

I. Re-fueling Pump

Wherever the usual facilities for refueling the airplane are not available, the fuel tanks may be filled by means of a Hand Refueling Pump located on the left side of the fuselage below the pilot's cockpit. The handle is reached through the bomber's emergency exit door in the bottom of the fuselage. Suitable lengths of hose, equipped with the proper fittings, are necessary to be used with this pump.

J. Repair of Riveted Fuel Tanks

Method for repairing riveted seams of fuel tanks is described on Page 5 of Appendix I. The compounds used for this purpose are given in Appendix IV.

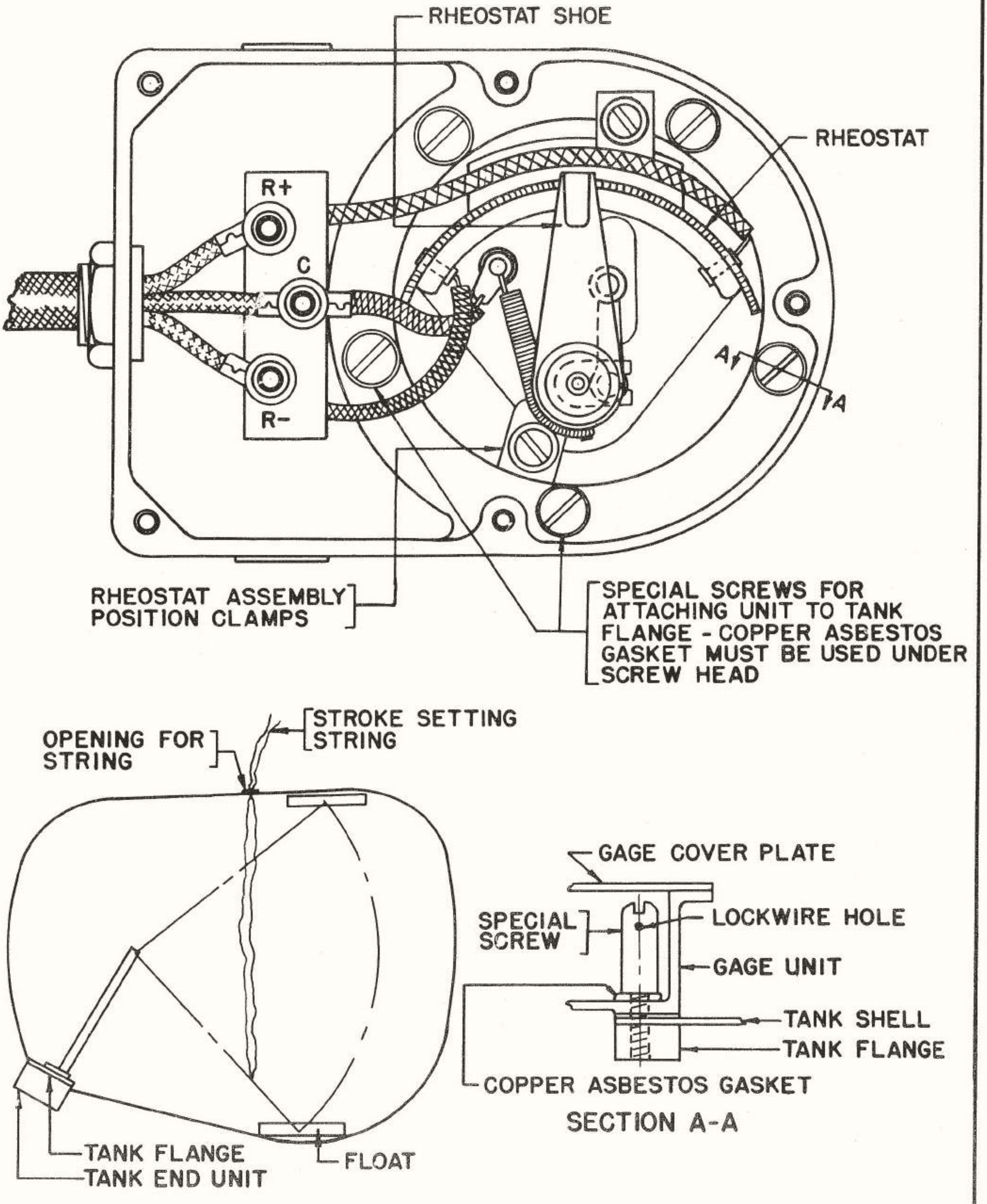


FIGURE 45 MODEL 139-W
LIQUIDOMETER GAUGE ADJUSTMENT DIAGRAM

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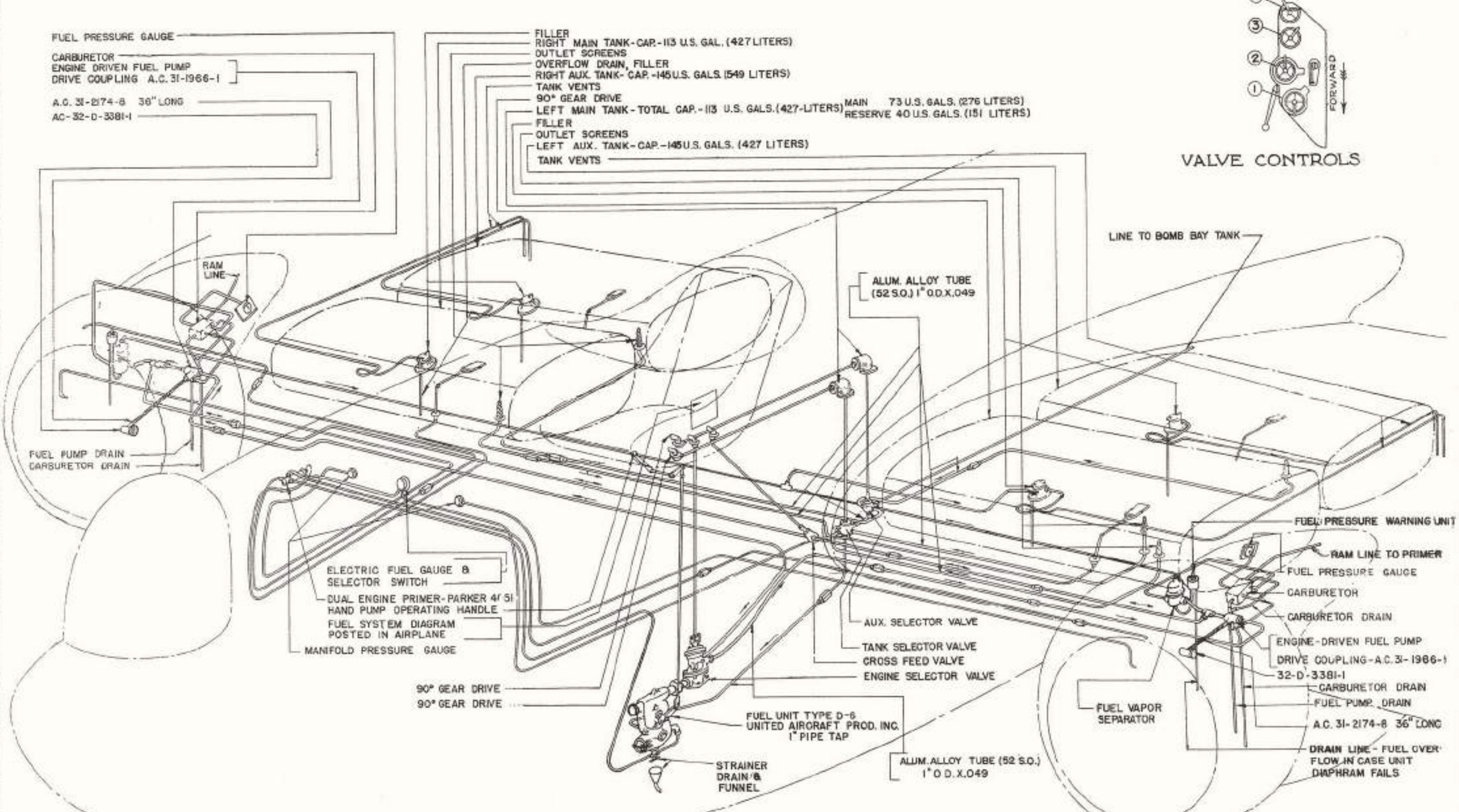

NOTE: ALL FUEL LINES ARE 5/8 O.D.X.049 ALUM. ALLOY (52 S.O.) EXCEPT AS NOTED
ALL TANK VENTS 3/4 O.D. X .035 ALUM. ALLOY (52 S.O.)
PRIMER LINES 1/8 O.D.X.025 COPPER TUBING
PRESSURE GAUGE LINES 1/4 O.D. X .032 COPPER TUBING

NOTE: (← →) ARROWS INDICATE DIRECTION OF FLOW
NOTE: SQUARE AROUND TUBING (⊏⊐) INDICATES HOSE CONECTIONS WITH AN. LINER

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FIGURE 46 MODEL 139-WH3 FUEL SYSTEM DIAGRAM

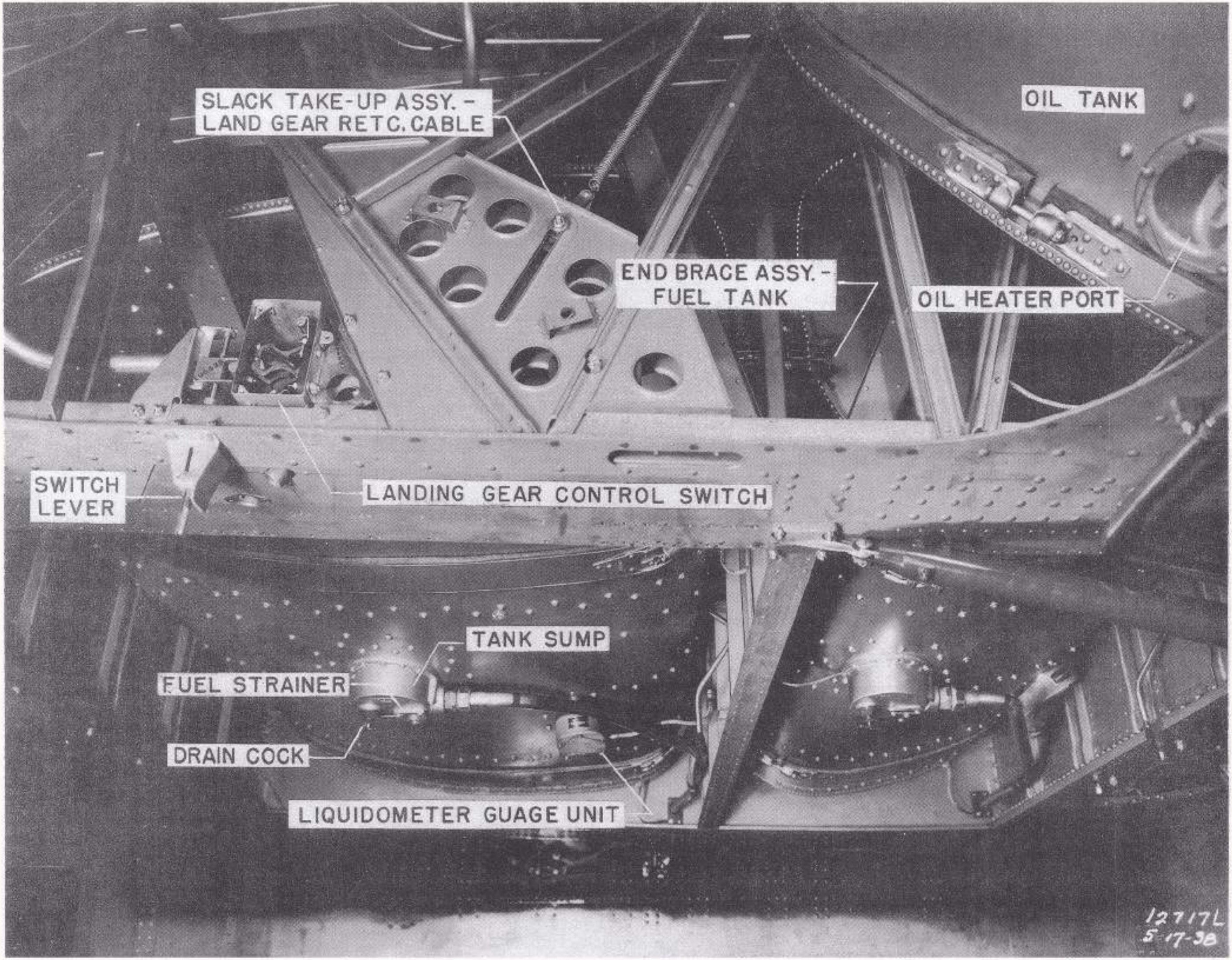


FIGURE 47 WING FUEL TANKS

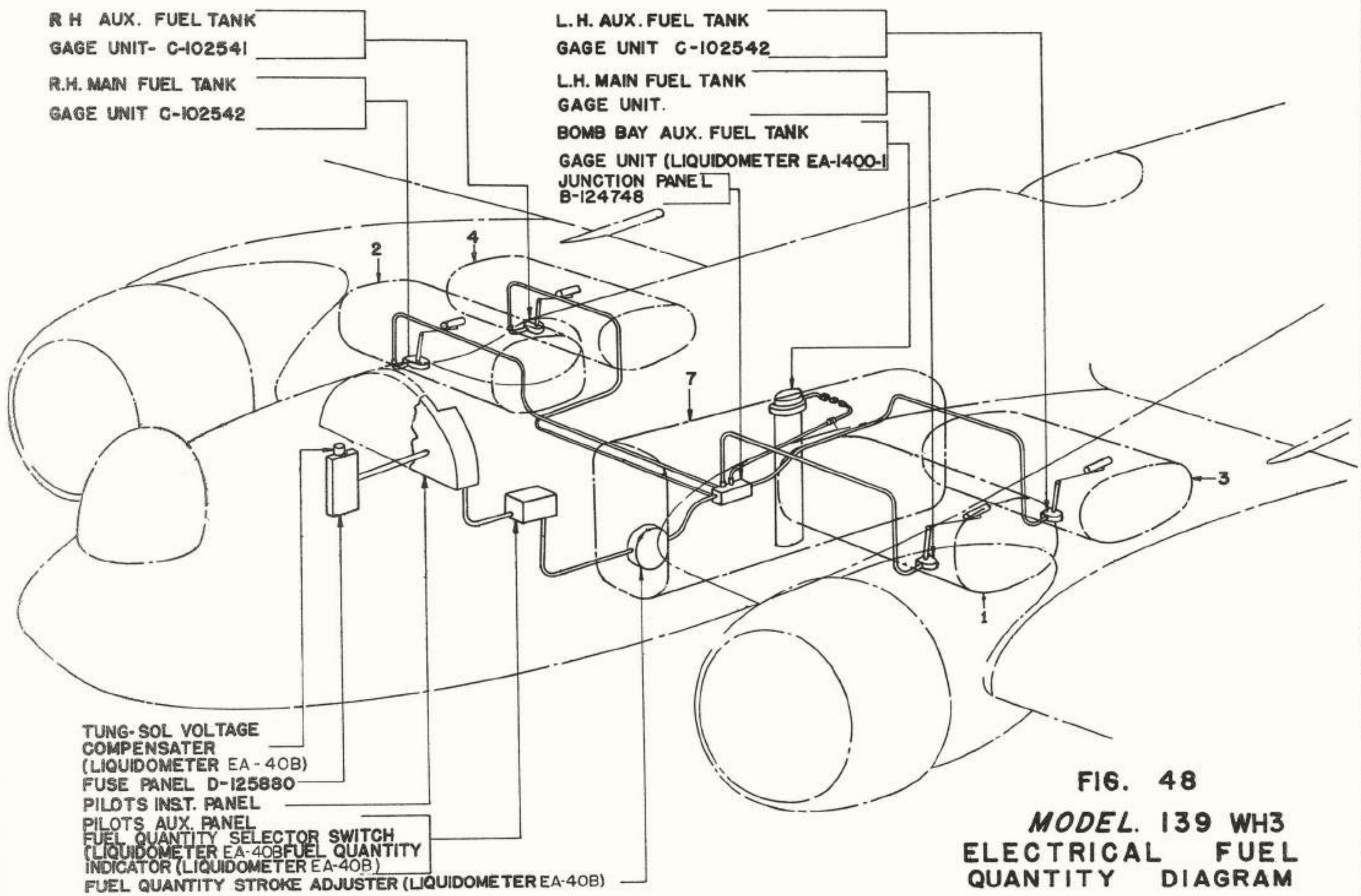


FIG. 48

MODEL. 139 WH3
ELECTRICAL FUEL
QUANTITY DIAGRAM

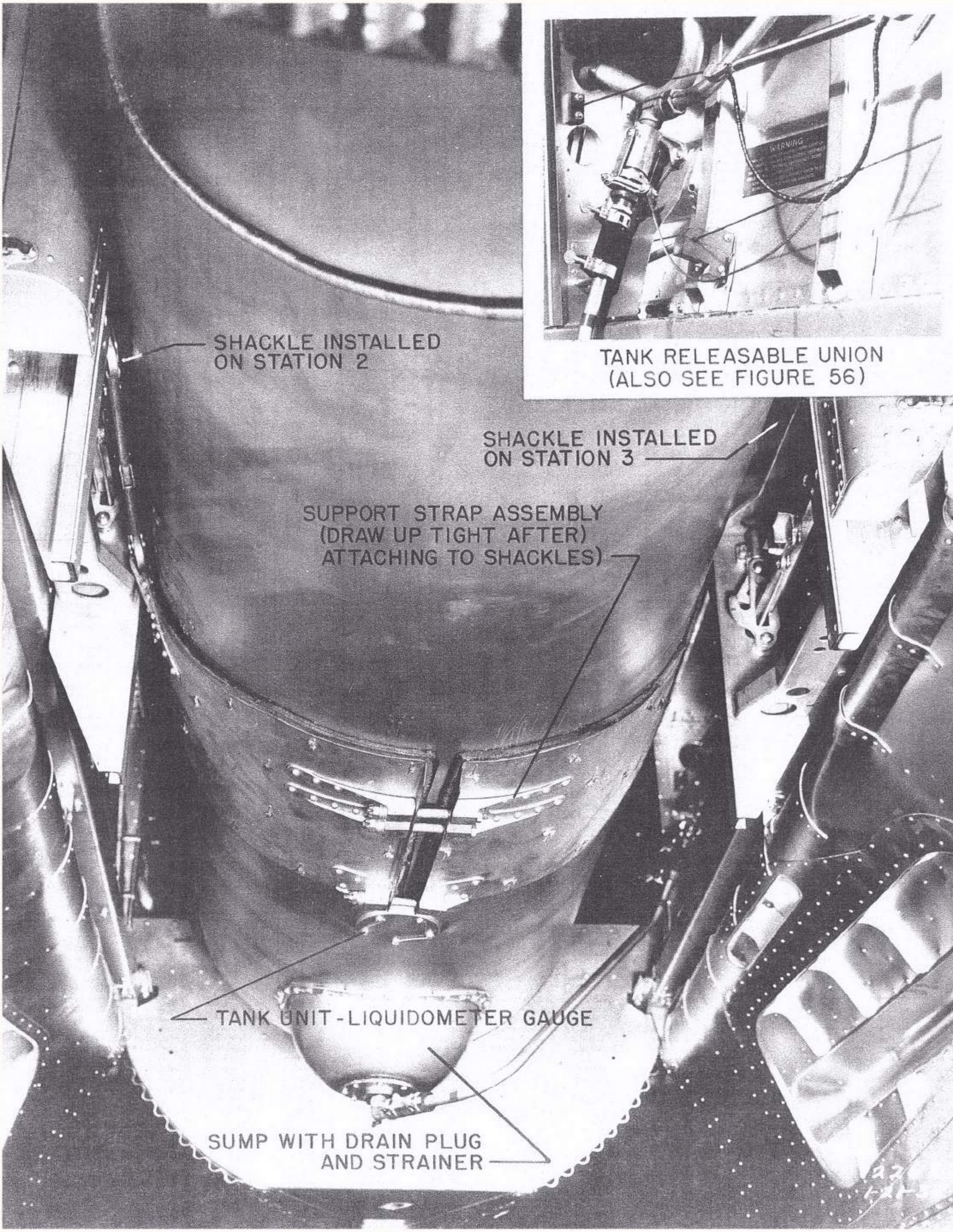


FIGURE 49 250 GALLON AUXILIARY FUEL TANK IN BOMB BAY A

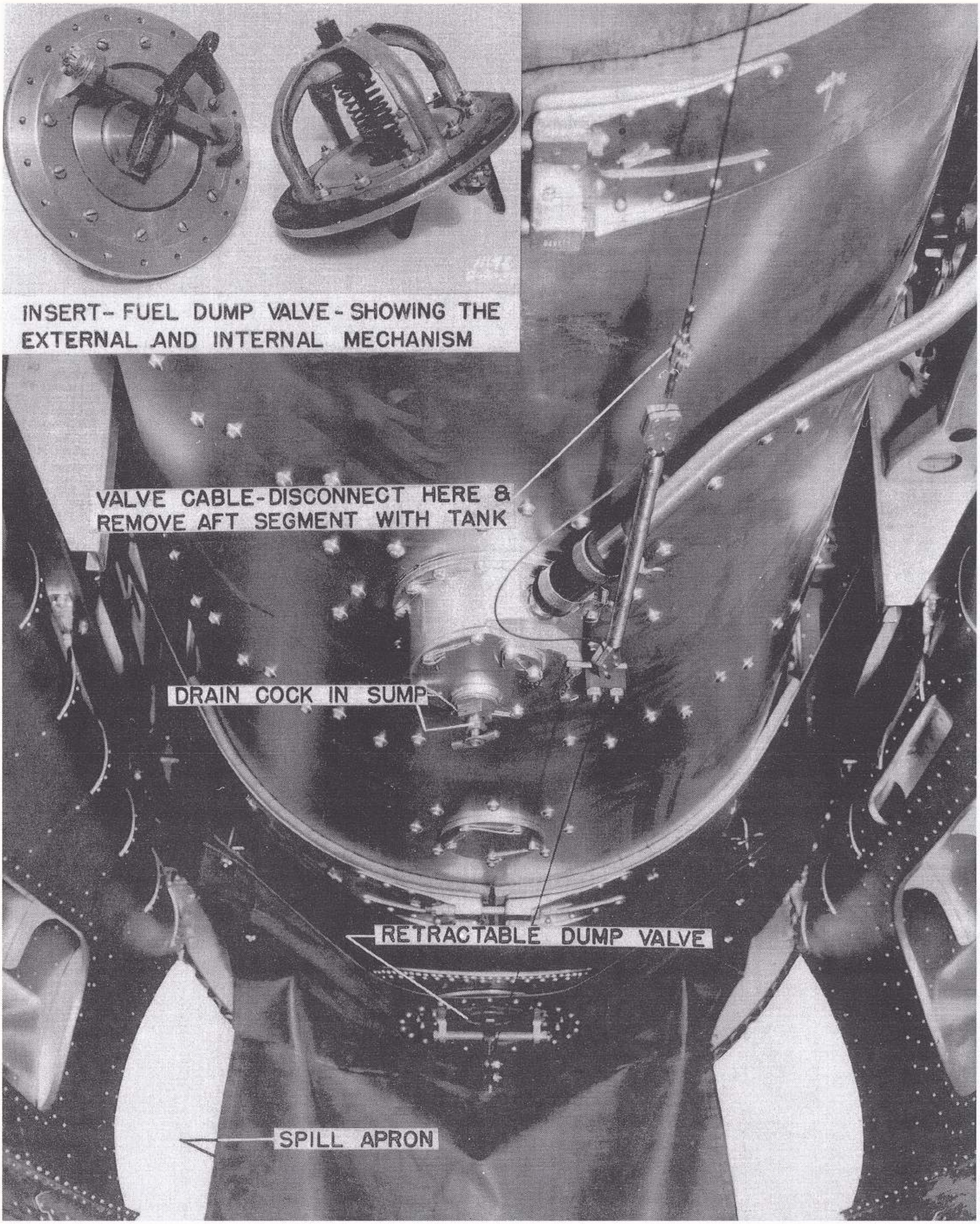


FIGURE 49-A 356 GALLON AUXILIARY FUEL TANK IN BOMB BAY

SECTION XII

OIL SYSTEM

A. Description

A self-explanatory layout of the oil system is shown diagrammatically in Fig.50.

B. Tanks

The oil tanks are of riveted aluminum alloy construction and have a capacity of 31.5 gallons (119 liters) each, plus an expansion space of 3 gallons (11.3 liters). They are carried behind the front wing beam in each nacelle as shown in Fig. 51. The tanks may be installed or removed through the wheel well opening in the bottom of the wing. The filler may be reached through a door in the top of the wing nacelle cowling. Provision has been made for a screw-in type electric heater.

> Note: These oil tanks have riveted seams that are filled with a sealing compound. Due to this construction, these tanks should not be cleaned with steam as this will loosen the sealing compound and cause the tanks to leak.*

The procedure for removing a tank is as follows:

1. Drain tank.

2. Disconnect outlet line at lower surface of wing and remove fittings from tank.

3. Disconnect oil vent and oil return through door in upper fixed cowl section on top of the wing and remove the fittings from the tank.

4. Remove the filler from the tank.

5. Disconnect the tank straps and remove the tank through the landing gear wheel well opening in the lower surface of the wing.

C. Oil Coolers

The oil coolers, (manufactured by the United Aircraft Products Corp. of Dayton, Ohio) are located in the leading edge of the center wing inboard of the engine nacelles. They are accessible through the doors on the under surface of the leading edge directly under the coolers. After the oil lines are disconnected, the units may be removed by taking out the bolts that secure the metal straps around the cooler. Each cooler is provided with a by-pass relief valve. This valve is set at the factory to pass cold oil through the jacket surrounding the cooler core when the oil temperature is 35°C or less. As the temperature rises, more oil is allowed to flow through the core proper until, at a temperature of 75°C. all of the oil flows through the core and none through the jacket. This valve is automatic in operation and normally requires no maintenance. This valve is thermostatically controlled and is not the spring-loaded pressure-controlled type.

*See Appendix I, page 5, and Appendix IV for repair of tank seams.

There are three oil by-pass valves in the system; the one described above, one at the oil pump to regulate the oil pressure, and one in the Cuno Oil Strainer located on the engine which by-passes the oil if the strainer becomes clogged.

An oil thermometer well is located in the line from the oil tank to the engine to indicate the temperature of the oil entering the engine.

D. Maintenance

1. Oil Temperature Regulators

(For instructions see United Aircraft Product Instruction Sheet.)

2. Inspection

Make daily inspection of all accessible lines for evidence of leaks; tanks and oil coolers for security of mounting.

Inspect oil system every 20 hours for breaks in lines, security of anchorage leaks at connections and clean drains. Inspect hose connections and replace if signs of deterioration are detected.

See Section XXIII for additional inspection.

E. Cold Weather Precautions

If the airplane is kept out of doors or in an unheated hangar during extreme cold weather, considerable time can be saved by draining the oil from the tanks as soon as operations for the day are concluded and before the oil has cooled off. Otherwise the oil may become so thick as to require considerable time to drain, particularly if left over night. In extreme cold weather the oil lines to and from the tanks may be insulated by wrapping them with a layer of asbestos cord, then shellacing and wrapping them with friction tape. Higher oil temperatures will then result at cruising speed and will decrease the danger of stoppage due to congealed oil.

F. Oil Immersion Heater (Optional Special Equipment)

The electric screw-in type Heater used for warming the engine oil to facilitate starting the engines in cold weather, is installed in each oil tank near the bottom. It may be reached through the wheel well. a $1\frac{1}{2}$" O.D. x $1\frac{1}{4}$" I.D. copper-asbestos gasket (AN-900-33) is used under the heater flange when it is installed, and should be renewed when it appears worn or excessively flattened.

The current is supplied through a slip-on plug connector from an outside source. The voltage required is stamped on the inner end of the heater unit. The wattage is 300.

IMPORTANT: As this type of heater provides very concentrated heat, it should never be left connected for any length of time when the element is not completely immersed in oil. If left operating in an empty tank or in a low level of oil, the heat will not be dissipated fast enough and the heater may burn out.

Note: This heater is made by the Edwin L. Wiegand Co., Pittsburgh, Pa.

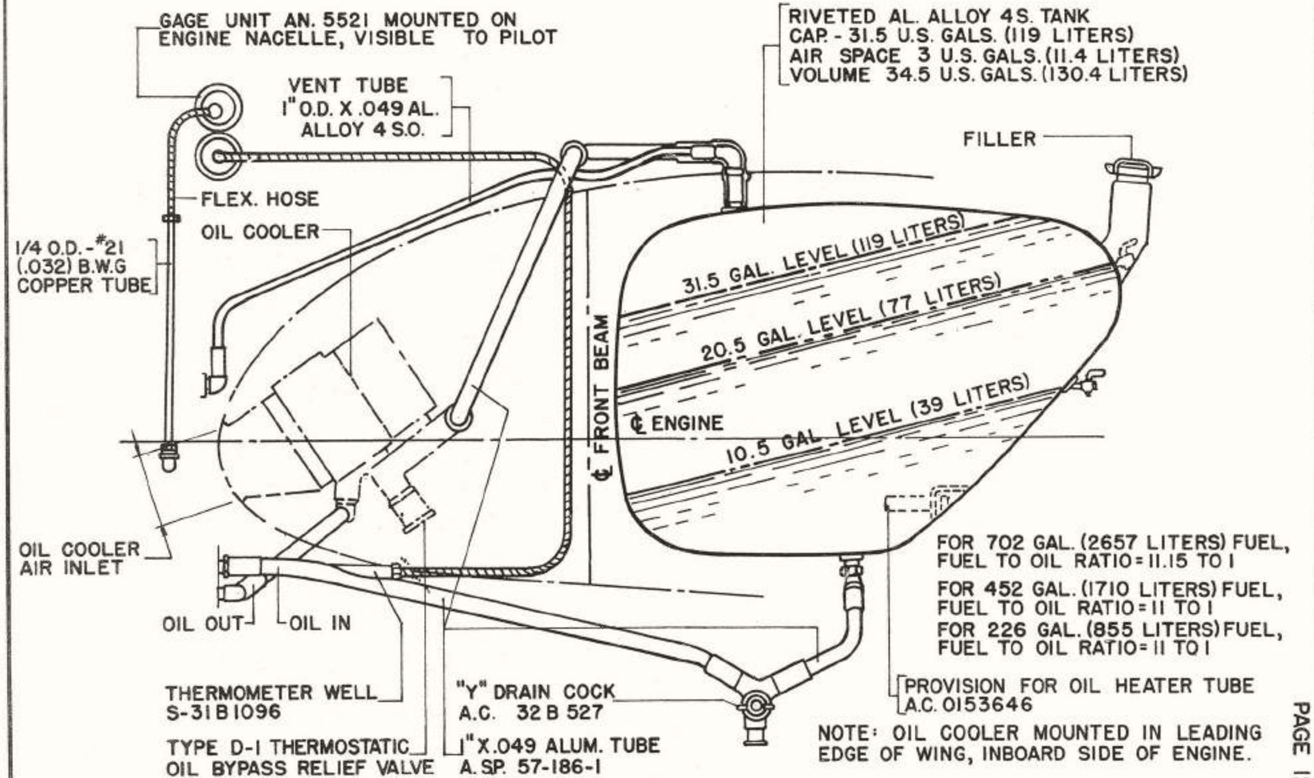


FIGURE 50 MODEL 139-W OIL SYSTEM DIAGRAM

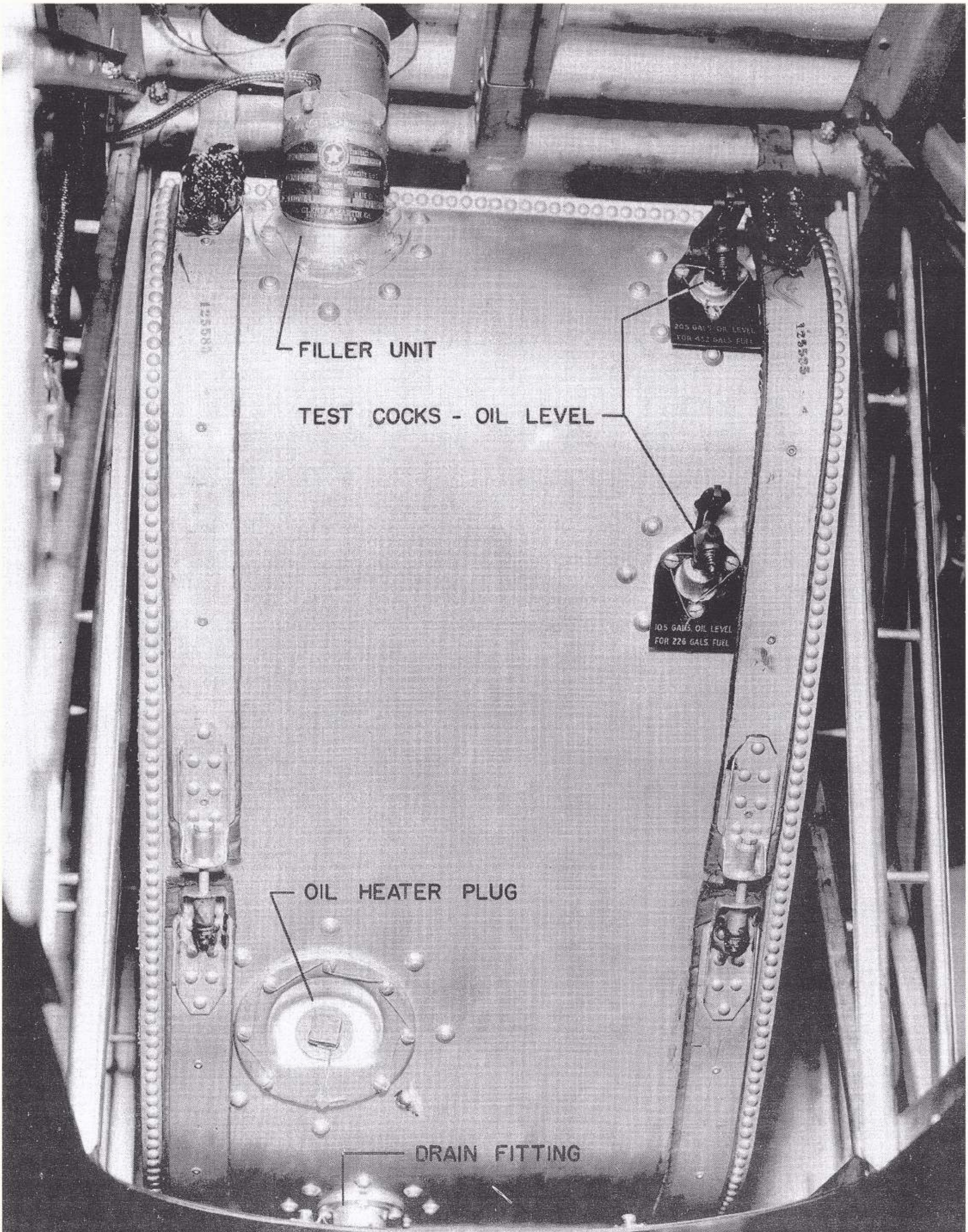


FIGURE 51 OIL TANK INSTALLATION

SECTION XIII

FUSELAGE EQUIPMENT

The equipment installations listed below are described and illustrated in separate sections as follows: Instrument Installation--Section XXI; Electrical Equipment--Section XIX; and Radio Equipment--Section XX.

A. Life Preserver Cushions

One Type A-3 pilot's back cushion and three Type A-1 seat cushions are furnished and installed. Each is capable of sustaining one man in water.

B. Relief Stations

Three relief stations are installed, one in the pilot's cockpit, one in the front gunner's cockpit, and one in the radio compartment. The two forward stations are mounted on the right side of the fuselage. The rubber tubing from each station is connected to a "Tee" from which a single tube leads to the suction venturi, mounted on the right side of the fuselage. The tube from the rear station is connected to a suction venturi mounted on the left side of the fuselage, beneath the wing trailing edge. This station is accessible to both the radio operator and the rear gunner.

C. Safety Belts

Seat type belts, Type B-10 and B-6 respectively, are provided for the pilot and rear gunner. The rear gunner, in addition, is provided with a single anchorage waist belt, Type A-3, to permit freedom of movement when he is engaged in gunnery operations. The front gunner is also provided with a Type A-3 belt.

D. Flight Report Holder

A Type A-2 flight report case is installed on top of the fuselage in the rear section of the pilot's enclosure. A map case is provided on the right side of the fuselage below the flap control handle. A canvas bag is installed on the left side of the fuselage above the emergency exit door in the bomber's compartment.

E. Pilot's Seat

A hinged bottom is incorporated in the pilot's seat to enable him to change places with other members of the crew. The seat is unlatched by operating the handle which is located on the bottom side near the front edge after the pilot has removed his weight from the seat. As a precaution against the inadvertent release of the seat, a 1/32' galvanized iron safety wire is wrapped around the operating handle and the adjacent locking rod. The seat may be raised and lowered as desired by operating the lever located on the right side of the seat. It is necessary to apply a slight pressure of the body to the seat when adjusting the height.

F. Fire Extinguishers - Hand

Two Aircraft Type "Pyrene" fire extinguishers are installed in spring clip brackets in the fuselage. One fire extinguisher is located to the right and aft of the pilot's seat on the top surface of the center wing section, and is accessible to the pilot's free hand. The other fire extinguisher is mounted in the front of the rear gunner's cockpit on the left side, and is accessible both from inside and outside the airplane although it is first necessary to open the sliding gunner's enclosure in order to reach this extinguisher from the outside.

G. Fire Extinguishing System-Pressure(Optional Special Equipment)

The separate "Lux" fire extinguishing system installed in each engine nacelle consists of the following major units: two high pressure steel supply cylinders for CO_2 gas and two spring actuated cutter valves for releasing the gas, a piping system installed around each engine for conducting the gas; and a control handle and cable system for manual operation of each cutter valve.

The supply cylinders are retained by means of padded clamp type brackets under the wings in the wheel wells. See Fig. 32. It is necessary that the left side of the nacelle fairing aft of the front spar be removed to inspect and service the cylinders.

The gas supply tubing is clamped to the engine supports and is shaped around the rear of the engine with one tube terminating in the carburetor air intake. This tubing is perforated throughout its length in the nacelle to allow an even distribution of the gas in the engine compartment. It is essential that the tubing be kept secure and that the perforations remain unobstructed.

The release valves are operated by means of two pull handles located in the pilot's cockpit, one in each side of the fuselage. They are painted bright red to be readily visible to the pilot. The control handle is connected to the control cable which runs through the cable tubing along the front spar of the wings to the release lever on the cylinder. "Lux" adjustable corner pulleys are used at all bends in the cables to minimize friction and to eliminate possible cable failure.

Detail operating and maintenance instructions are contained in the "Instruction Book for Lux Systems" accompanying this Handbook. (See Appendix II.) These instructions should be rigidly adhered to in maintaining this system. In addition, the 40 hour inspection period should provide for a thorough inspection of the entire control system to ascertain the security of all parts, cleanliness of the expellant tubes and the condition of the gas supply. When re-installing the supply cylinders, be sure that the felt padding in the clamp brackets and between the wing skin and cylinder are in good condition as well as secure.

H. Life Rafts(Optional Special Equipment)

A five man "Inflatex" collapsible rubber boat, complete with 2 oars, hand pump, two CO_2 bottles, rope, and packing case is stowed in the top of the fuselage aft of the rear gunner's cockpit above the floor gun.

The boat consists of a strong, tough, waterproof duck casing enclosing large, seamless dipped latex bladders that are removable and replaceable. The bladders are anchored to the casing at several points to insure correct inflation. They are about the same size as the casing and are under no strain when inflated to the casing size.

The two gas cylinders are connected to nipples provided in the boat, one nipple for each side of the boat as shown in Fig. 53. The hand pump is used to maintain the pressure in the raft for an extended period. The gas cylinders should be checked by weighing every 6 months and should equal the values stenciled on each bottle.

Stowage facilities in the airplane consist of two adjustable straps equipped with quick release buckles providing ready release of the life raft. The stowage provisions are shown in Figure 52.

I. Oxygen Equipment

Complete provisions have been made in the airplane for two installations of Siebe, Gorman & Co., Mark VII, Hand-controlled gaseous type oxygen breathing apparatus as shown on drawings listed in Appendix III A schematic layout showing the method of assembling the necessary components as used by the pilot and front gunner-bomber is shown in Figure 54 . The rear position equipment comprises a similar installation. Figure 55 shows the equipment as it is installed in the airplane.

The oxygen is supplied from two sets of interconnected "Vibrac", special alloy steel cylinders of 750 liter capacity each. The forward cylinders are clamped in a bracket located at the lower left side of the fuselage below the pilot. Two universal torque shafts having a friction clamp at the lower end for attaching to the cylinder valves provide remote control to each bottle from two handles installed on the floor section aft of the left rudder pedal. The rear cylinders are clamped in two brackets located on the left side of the fuselage below the co-pilot's rudder pedal. The valves for these cylinders are operated directly. A system of high pressure copper tubes and fittings connect the cylinders to electric heaters, one to be located on the right side of the fuselage opposite the pilot, and one to be located on the left side of the fuselage above the rear cylinders and close to the co-pilot. The heaters are provided to prevent freezing of the oxygen at high altitudes. They are each operated by means of a Cutler Hammer toggle switch Type 820K1, installed adjacent to the heaters. Wiring connections for the heaters are made in accordance with the electrical wiring drawing (App.III). The auxiliary switches should be kept in the "off" position except when the heaters are in use.

Provision is made for mounting a high pressure supply gauge between the cylinders and the heater. A supply control valve is to be mounted directly above the heater in each case. Low pressure aluminum tubes are installed in the airplane to be connected from the control valves to the quick release bayonet unions where the mask hose connections are made. The bayonet unions are located at the left of the fuselage in each case as follows: In the bomber's compartment opposite the forward gun; in the cockpit on the rudder support tube in front of the pilot; on the side of the fuselage opposite the radio operator; and on the side of the fuselage opposite the commander's station.

Provisions for mounting a low pressure gauge or flowmeter adjacent to each bayonet union are made. The flowmeter indicates the flow of oxygen in terms of altitude; it is graduated in thousands of kilometers.

IMPORTANT: THE USE OF ANY KIND OF OILY COMPOUND OR FLUID WHEN MAKING CONNECTIONS OR FOR TESTING THE EQUIPMENT IS POSITIVELY FORBIDDEN AS AN EXPLOSION MAY RESULT.

Maintenance of the equipment consists chiefly of keeping the bayonet unions and connector fittings cleaned, especially of oil and grease. When changing the supply cylinders, inspect the flared ends of the connector unions to see that they are not excessively worn. Tests for leaks may be made by opening the valve on the supply cylinders to produce a pressure at the gauge. A drop in pressure at the gauge after closing the valve is an indication of a leak in the system. This may be remedied by drawing up the nuts of the connector fittings starting at the cylinders. Tightening should be guarded against and the tube replaced if a leak is persistant.

Oxygen lines are identified by the green bands painted on them.

Additional information on the operation and maintenance of this equipment may be obtained from the Siebe, Gorman & Co., Ltd., London, England.

J. Bomber's Ladder

Passage to and from the bomber's compartment is had by means of a folding combination ladder and floor grate which is hinged to brackets at the aft end of the entrance door. When the ladder is folded together, it can be secured in a horizontal position above the door by means of latches at the end of the side braces. A walkway is thus provided from the bomber's to the pilot's compartment. Important: Do not step on the doors as they will not support a heavy weight. When the bomber's compartment is occupied during flight, the ladder should be folded up and stowed against the bulkhead curtain. A spring clip fastener is provided to hold it in this position. This will permit an unobstructed exit in an emergency.

K. Bomber's Seat

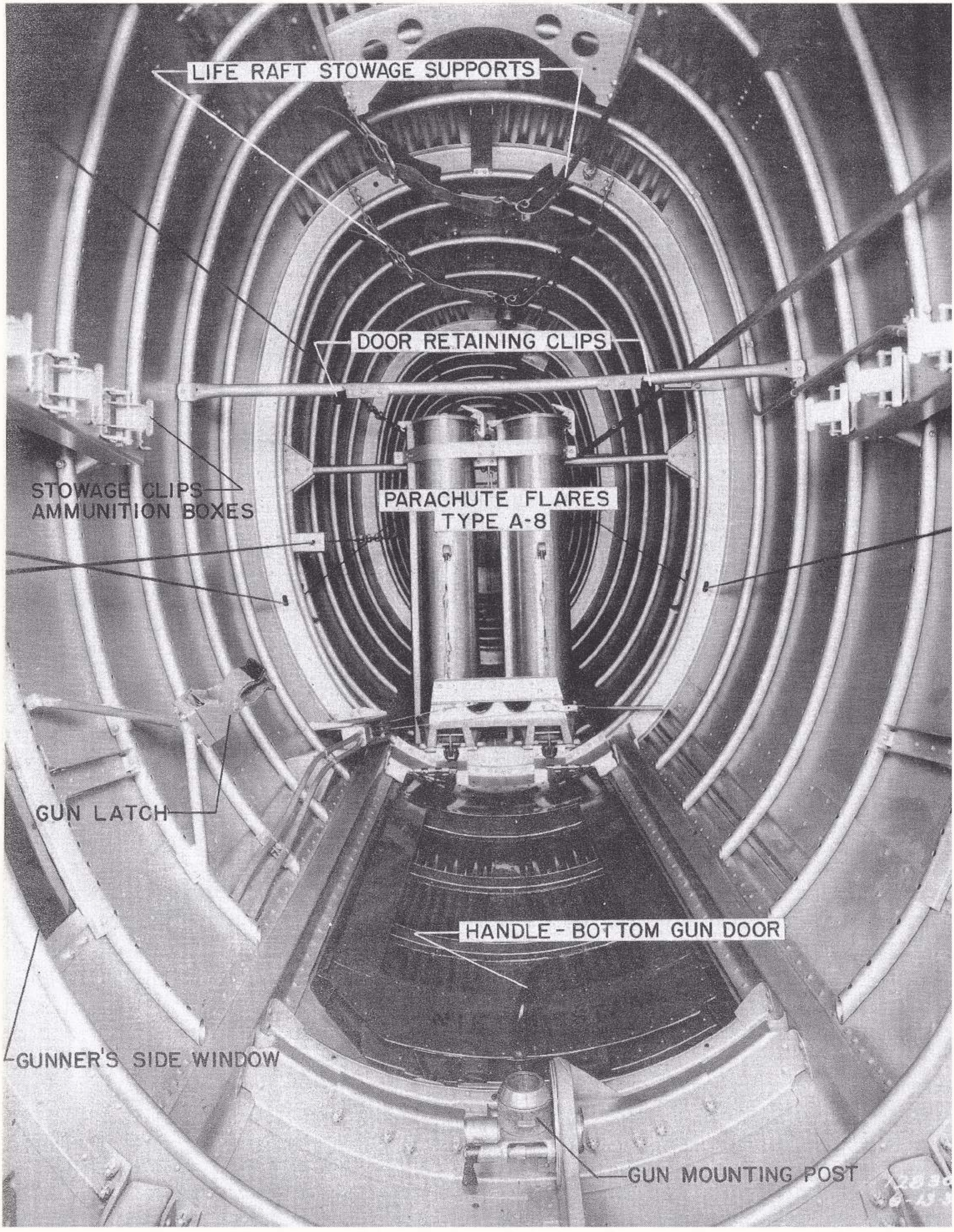
A fold-up type seat is installed in the nose with two legs hinged to the floor at the left side of the fuselage. The other legs are secured to channels on the floor so that the seat can be extended out for use during bombing operations.

L. Ventilator - Pilot's Cockpit

Outside air can be taken into the front cockpit through a scoop type ventilator provided in the right side of the fuselage above the landing gear handcrank. The scoop is hinged to roll outward into the air stream. A latch is provided with which the scoop can be locked in various open positions.

M. Message Carrier

Communications, maps, flight data, etc. can be shuttled between the front and rear cockpits by means of a message carrier. This device consists of a flat piece of fibre installed on a slide which is secured to a square tube located on the top right side of the fuselage. Spring clips are provided to hold messages on the carrier. A handcrank is installed on the right side of the front cockpit above the ventilator, and on the rear cockpit coaming above the control column for operating the carier on the tube. The operating cable connected to the carrier is wound on a pulley at each handcrank. Tension is maintained with a turnbuckle at the carrier.



C

FIGURE 52 FUSELAGE TAIL SECTION - LOOKING AFT

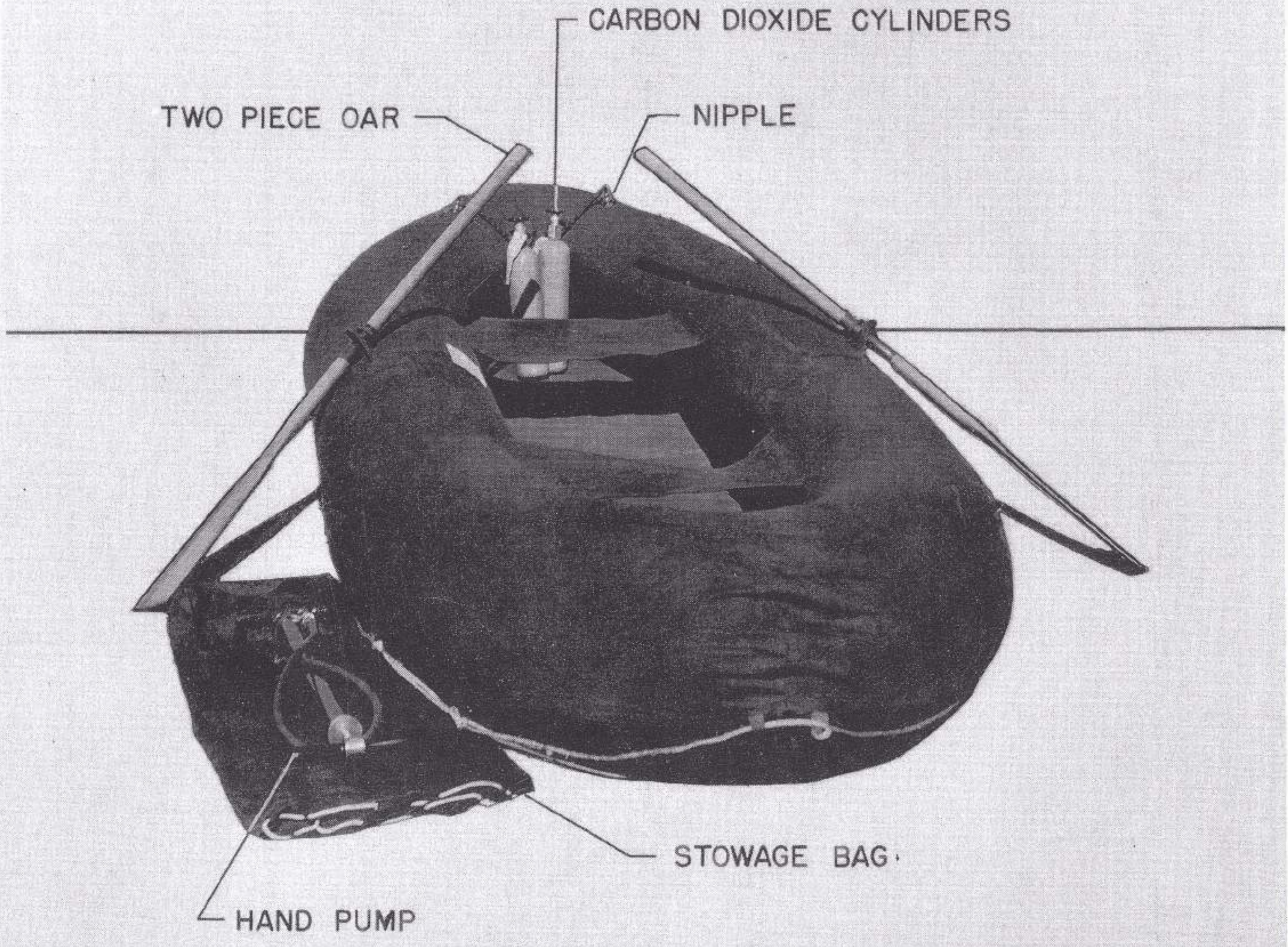
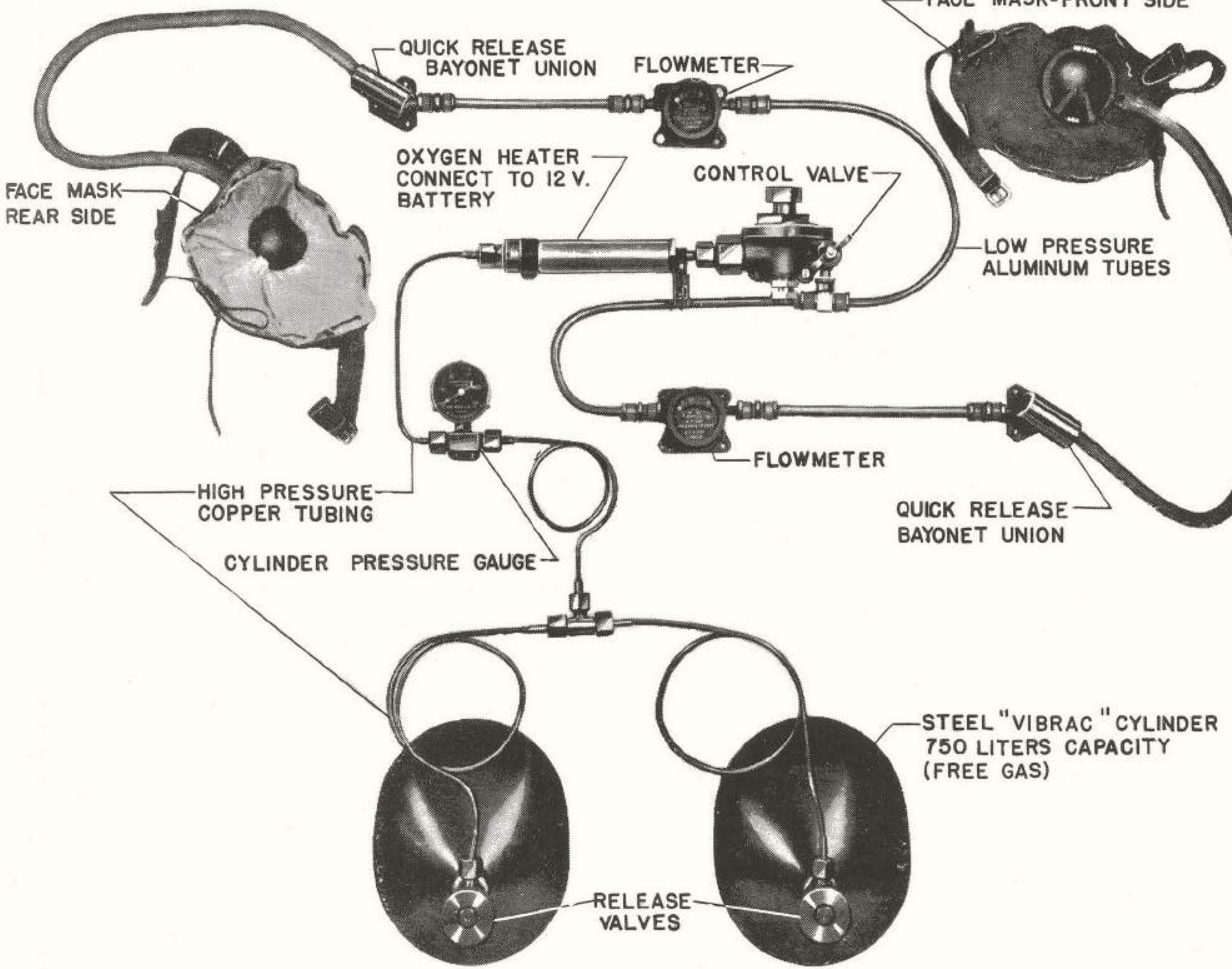
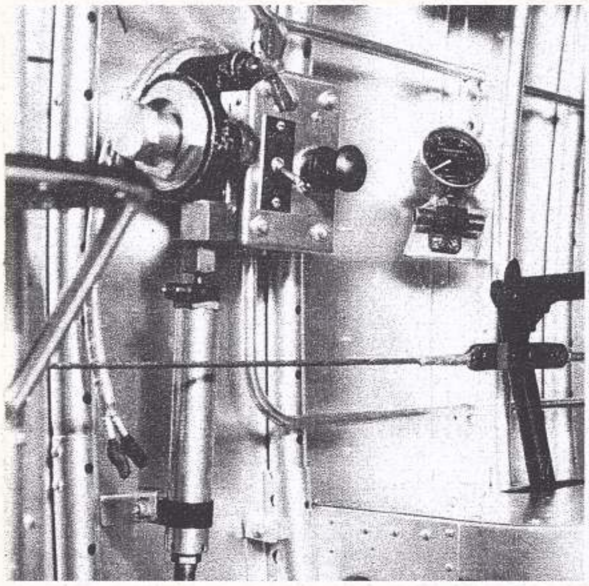


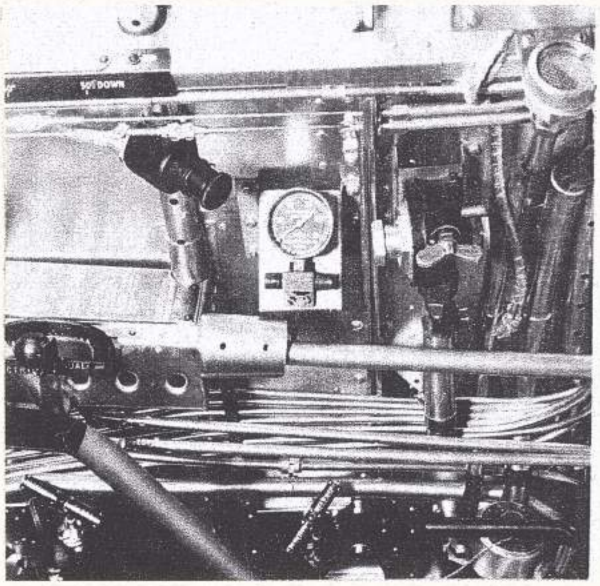
FIGURE 53 "INFLATEX" LIFE RAFT INFLATED



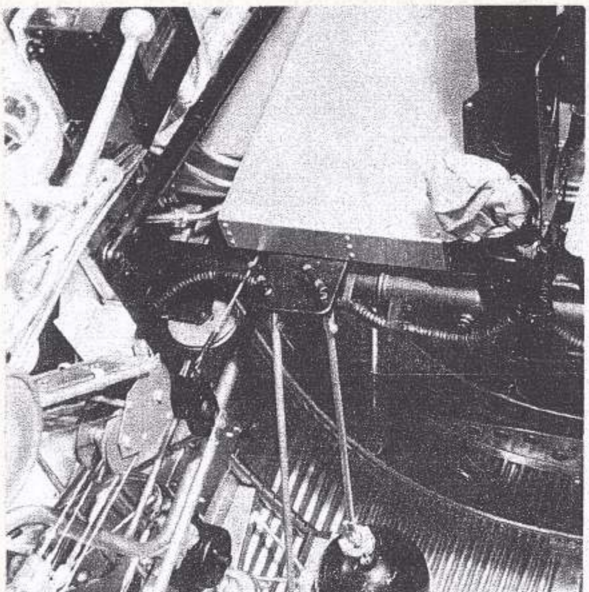
A

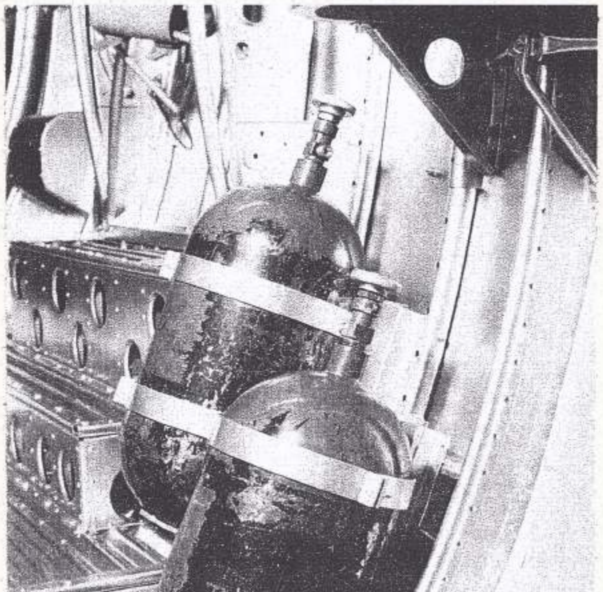
FIGURE 54 ARRANGEMENT - SIEBE GORMAN MARK VII OXYGEN APPARATUS





CO-PILOT'S — OXYGEN CONTROLS — PILOT'S





FORWARD CREW — SUPPLY CYLINDERS — REAR CREW

A

FIGURE 55 OXYGEN EQUIPMENT - GENERAL ARRANGEMENT

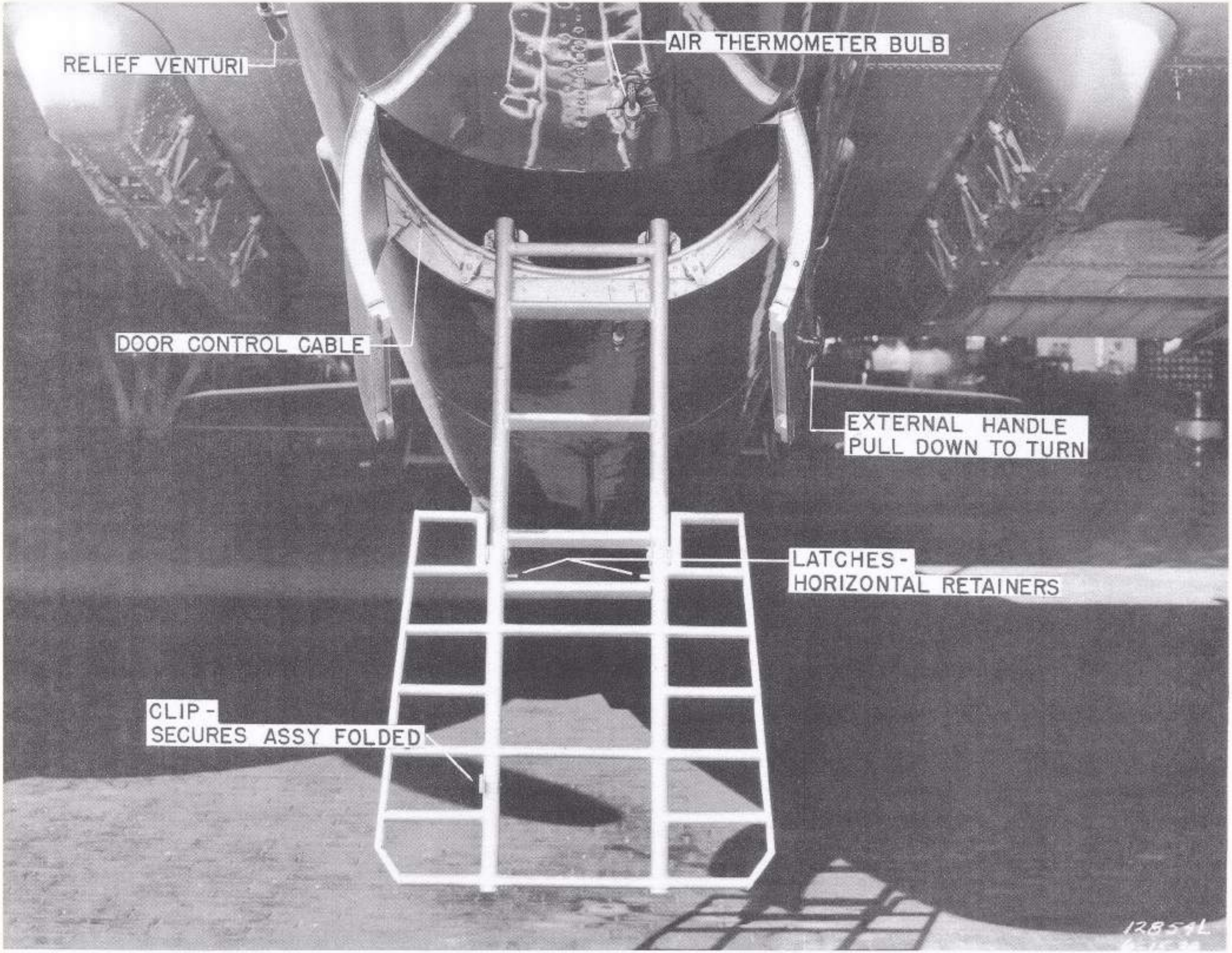


FIGURE 55-A INSTALLATION BOMBER'S LADDER AND COMPARTMENT DOOR

SECTION XV

BOMB INSTALLATION*

A. General

1. Internal Bomb Racks

The equipment provided in these airplanes for carrying and releasing bombs from the internal racks consists of the following:

1 Type G-10, Modified, electrical release and mechanical emergency release
9 Type B-5A, Modified Bomb Shackles
1 Bomber's Release Handle with "Locked", "Selective", and "Salvo" positions
1 Type B-3 Arming Handle
2 Type A-3 Emergency Release Handles (one each for Pilot and Radio Operator)
2 Type C-2 Bomb Hoist Units (one left hand and one right hand)
1 Bomb Load Indicator
Electric Release Switches (Bomber Only)
Provision for the installation of a Goerz Bomb Sight

The installation of this equipment, excepting the bomb sight, is shown in diagrammatic form in Figure 56. Other views of the internal bomb rack installation are shown in Figures 58, 59, and 60.

Dimensional clearances are provided in the airplane for the following listed sizes of bombs manufactured by the U. S. Ordnance Engineers, Inc., Cleveland, Ohio; and standard export types:

2 bombs at 1130 lbs. (512.5 kg.) each, or
3 bombs at 625 lbs. (283.5 kg.) each, or
5 bombs at 285 lbs. (129.3 kg.) each, or
9 bombs at 122 lbs. (55.3 kg.) each.

B. Bomb Rack Mechanism - Internal Rack

1. Description

Normal operation of this bomb rack is by means of electric switch controls provided for the bomber. A complete description of these switches is given in Section XIX-A which covers the Electrical Installation of the racks. A description of the bomber's mechanical controls and the pilot-radio operator's emergency mechanical controls is given in the following paragraphs.

The internal rack consists of two hanger assemblies bolted to vertical girders on each side of the bomb bay as shown in Figure 58. Each hanger consists of a front and rear rail made from 24ST aluminum alloy extruded section, rigidly spaced apart by means of formed metal spreader bars. Latch hooks are installed on the inner side of each rail from which the bomb is hung in place by means of the modified Type B-5A shackles. There are five bomb stations provided on the left hand rack and four on the right hand rack, each station being identified by a number stamped on the outer side of the rear rail. The size of the bombs which may be carried on the racks in accordance with the list in paragraph "A" is also shown on the rear rails. Other loads may be carried if desired.

*For External Bomb Rack Installation see Paragraph J of this Section.

Each bomb station is equipped with an electric release mechanism for tripping the shackles either selectively or salvo. An emergency salvo mechanical release is also provided, paragraph G-2. The electric release mechanism consists of a slide bar which supports the "arm and safe" control bracket and the shackle release bracket; a heavy duty tripping solenoid rigidly installed on the front rail; a strong compression spring retained on the trigger release rod; and a trigger mechanism. The assembly is diagrammatically shown in Figure 56. The trigger release rod is connected by means of a link to the sliding bracket which operates the release lever of the bomb shackle providing the station has been cocked. Before a bomb is loaded, the trigger release spring must be compressed and the trigger set in the latched position. When the station is released either electrically or manually, the trigger is tripped by a cam on the solenoid, releasing the compression spring and the bomb hooks in the shackles.

2. Release Control System

Each station of the rack is remotely connected by a link rod which is supported by levers installed on the front rails at each station. The lever is indicated by the letter "C" shown in View A-A, Figure 56. The lever "C" operates between two ferrules provided on the solenoid plunger rod thereby affecting the action of the solenoid in relation to the position of the link rod. The link rods are connected at the top by means of bell cranks and push rods to a clutch mechanism located on the right side of the bomb bay. See Figures 56 and 59. The clutch is normally operated through a cable system by the bomber by means of a release handle located on the right side of the fuselage in the bomber's compartment.

The control handle (Figure 60A) is provided with three positions: "Lock","Selective", and "Salvo." When placed in the "Lock"(forward) position,the link rods on the racks are raised until the levers "C" are against the rear ferrule onthe solenoid plunger extension rod as shown B-B of Figure 56. The cam lever "B" in View A-A is held against the trigger lever "A" preventing the solenoid from operating electrically.

When the release handle is placed in the "Selective" position, the link rod and lever "C: are then placed in the position shown in View A-A of Figure 56. Lever "C" is then midway between the ferrules on the solenoid plunger extension which allows the solenoid to pull the cam "B" forward when the solenoid is energized, thus releasing the trigger and trigger release rod. This sequence of operations is repeated at each successive cocked station when the bomber energizes the circuit alternating from one hanger to the other providing stations are cocked on opposite racks. If stations are cocked on one rack only, the operations follow successively through the cocked stations starting at the bottom of the rack.

When the release handle is placed in the "Salvo" (rear) position, the levers "C" mechanically operate the solenoid plunger extensions simultaneously releasing all stations that are cocked. Since no bomb can be hung on the rack without cocking the station, the entire complement of bomb will be released when salvoed. The bomb racks may also be salvoed electrically with the release handle in the selective position, by operating the bomber's "Train" release switch. See paragraph B, Section XIX-A.

3. Clutch

The clutch mechanism is provided with three grooved pulleys around which the operating cables are wound and anchored. The small rear pulley is provided for the cable which is attached to the tension spring located above the clutch for returning it to the normal position after an emergency release.

The outer pulley is free floating unit on the supporting shaft and is controlled by means of the cables connected to the bomber's release handle. This pulley is always under a compression load provided by a light coil spring on the shaft bearing against the outer surface. The intermediate pulley is similar to the outer pulley and provides the anchor unit for the emergency bomb release cable.

The bomb rack link rods are remotely controlled by the long lever installed between the two outer pulleys of the clutch. This lever is equipped with a rigid steel pin inserted through the lever midway between the link rod and the pivoting connection at the opposite end. The pin rides in a slot provided in each of two cams installed in the adjacent sides of the two outer pulleys. Normally the pin engages the slot of the outer pulley so that the movement of the bomber's release lever is directed through the mechanism to the link rods. If the emergency controls are operated either by the pilot or the radio operator, a cam on the intermediate pulley moves the outer pulley back against the compression spring disengaging the pin from the slot and at the same time engaging the slotted cam on the intermediate pulley with the pin. When the emergency controls are released, the clutch mechanism returns to its original position.

A diagrammatic description of the clutch movement is shown in Views E-E and F-F of Figure 56.

4. Cocking the Trip Unit

Before loading any bombs on the rack the stations that are to be used should be cocked. This is accomplished by means of a cocking wrench which is stowed on top of the horizontal beam just behind the right hand hanger assembly. The wrench is engaged with the hexagonal fitting provided on top of the lever above each tripping unit assembly and then turned until the station cocks. The B-5A shackles cannot be installed or removed unless the station is cocked.

5. Automatic Skip Station

During selective electric operation of the rack, the stations not cocked will be automatically skipped. This action is described in detail by the three position sketches shown on Figure 67A. Cocking a station energizes the circuit to the indicator lamp in the bomber's compartment conveying to the operator the installation of a bomb on the corresponding station. This may result in a vain attempt to release a bomb from the station or in any case will require a separate impulse of the release switch to uncock the station.

6. Arming Controls

The "arm" and "safe" control brackets on the bomb racks are operated by means of cables from a Type B-3 Arming handle installed aft of the bomber's release handle. The cables are connected to a lever operating a transverse control rod installed on the upper end of the rear hanger rails. Each station is equipped with a support bracket and lever assembly which is riveted inside the rear rails of each hanger. The inner arms of the levers are interconnected by means of a control rod which is connected at the upper end to the transverse rod. See Figure 59.

The bomb shackle is equipped with two hooks which control the arming wire in the nose and tail fuses in the bomb. One hook is retained in the shackle under a light compression spring and is moved past a slot in the bomb shackle when the bomb hooks are locked shut. This hook retains the fuse wire in place in the shackle but is not strong enough to pull the wire from the fuses when the bomb is released. The second hook is pinned in the shackle opposite the wire retainer hook and is equipped with a lever which is operated by the sliding bracket on the rack. This hook can be moved under the wire retainer hook thereby locking the wire to the shackle so that it will be drawn from the fuses when the bomb is released.

When loading bombs on the racks, the bomber's handle must be in the "Safe" position. This is very important since it is otherwise possible to install the bomb shackle on the rack with the arming lever out of the sliding bracket. If installed in this condition, the bracket will not move the arming hook into the lock position and the bomb will be released "safe." Full operation of the bomber's control handle from the "Safe" to "Arm" position is necessary to operate the mechanism.

C. Electrical System

For the description of the electrical system on this bomb rack see Section XIX-A.

D. Bomb Sight

Provision has been made in the floor of the bomber's compartment for the installation of a Goerz Bomb Sight. The port hole for the sight is kept closed when the sight is removed by means of a floor plate and hole cover assembly. This cover is installed from inside the fuselage and is secured in place with screws. When the cover assembly is removed, the bomb sight mounting base can be secured to the floor by three bolts for which holes are provided in the floor structure. Complete Installation, Operation, and Maintenance instructions are furnished by the manufacturers of the bomb sight.

E. Hoisting Bombs

The bombs are loaded on the racks by means of the Type C-2 hoisting units. The hoists are carried in the airplane, stowed in hangers provided in the crown of the fuselage above the bottom rear gun. See Figure 60A. These units are either left or right hand and must be installed on the proper bracket under the wings and on the side of the fuselage. See Figure 57. When properly hooked in the mounting brackets, the hoists will be horizontal when the airplane is resting on the ground.

IMPORTANT: The drums must be assembled on the brackets so that the cable grooves of the drums are to the rear with the cable leading off close to the fuselage as shown in Figure 57.

Hoisting pulleys are swung from ball socket fittings in the top of the bomb bay as shown in Figures 56 and 59. These pulleys are arranged so that any of the bombs shown in the loading diagram, Figure 56, can be hoisted into position. When the hoists are installed, the cables are fed through the slots in the sides of the fuselage up through the cable guides and over the pulleys.

The aft set of pulleys are used for hoisting bombs on the upper left hand station #9 only, and the forward set of pulleys should be used for hoisting bombs on all other stations. This is essential since hoisting with the proper pulleys will eliminate having to swing the bomb through a large angle in order to engage the shackle with the hooks on the hangers.

When hoisting 300 lb. (129.3 kg.) bombs, the center pulleys are used in addition to the forward set. The 100 lb. (55.3 kg.) bombs are loaded by hand. Slings are provided for hoisting the various types of bombs and are stowed in the airplane.

The shackles should be installed on the bombs and the arming wire inserted over the inner hook before the bombs are hoisted into the fuselage. In cases where the bombs are fused after being hung on the rack, it is more desirable to have the fuse wire in place in the shackle before the bomb is hoisted.

IMPORTANT: As shown in View G-G of Figure 56 which indicates the position of the shackle as installed on the right hand rack, the bomb hooks must always point aft. The word FRONT stamped on the shackle should be closest to the nose of the bomb in any case.

It will be necessary to remove the front and rear support braces for the bomb bay fuel tank before large bombs are hoisted onto the racks.

F. Fusing Bombs

Access holes are provided through the wing spars in the bomb bay to permit the fusing of upper bombs after they are hung on the racks. Extreme caution must be used while inserting fuses in bombs in the airplane. If it is necessary to fuse bombs through the hole in the front wing spar, the pins in the lower end of the pilot's seat support should be removed and the seat hinged forward about the upper attaching pins.

IMPORTANT: The tail fuse on the upper 1100 lb. (512.5 kg.) bomb cannot be inserted after the bomb is on the rack due to interference at the wing spar.

All bombs may be fused while on the ground if desired and the propellers carefully locked by means of the arming wire.

G. Bomb Bay Doors

The bottom of the bomb bay is closed by means of two doors which are hinged to the longerons at each side of the fuselage. These doors are of riveted aluminum alloy box type construction strong enough to permit their being walked on. For this purpose a smooth skin covering is provided on the inner surface of the two halves. As a matter of caution, members of the crew passing through the bomb bay in flight should find support at the fixed parts of the structure. Each door is attached to the fuselage by four hinges having zerk fittings for applying lubrication. These fittings are accessible from the inside of the bomb bay when the doors are open.

1. Operating Mechanism

The bomb bay doors are operated by means of a large steel screw and special split nut mechanism which is mounted vertically on the front bulkhead in the bomb bay. A push rod is connected to each side of the nut and to a strut arm which is integral with each door. The screw is operated through a system of universal torque shafts and gear assemblies, carrying the nut up and down the screw and controlling the doors through the displacement of the struts. See Figure 58 . The torque shaft can be operated by the bomber with a hand crank located on the right side of the fuselage above the emergency exit door; and by the radio operator with a crank located on the right side of the fuselage above the drift sight window.

2. Emergency Operating Mechanism

The nut which travels on the screw consists of a threaded split block with the halves retained between two flat steel plates which operate the cams to open and close the nut. The plates are connected by means of levers to a grooved roller cam which is loosely keyed to a straight support shaft adjacent to the screw. The roller cam follows the nut mechanism as it is moved by the screw. A pin is provided on the control lever and is retained in the groove of the roller cam thereby providing a means for operating the cam plates which control the nut. The supporting shaft for the roller cam can be rotated by a cable controlled drum installed on the upper end of the shaft. When it is rotated, the pin on the nut control lever follows the groove in the roller cam, the first part of the rotation splits the nut and opens the doors, and the remaining travel of the cam permits the continued pull on the control cable to release the bomb racks.

The emergency release cable to the shaft drum is carried along the right side of the fuselage and is splice connected to two emergency release handles located as follows: In the pilot's cockpit just forward of the wing flap control valve, and in the radio operator's compartment on the bulkhead just aft of the door crank. An additional cable is wound on the shaft drum opposite to the release cable and is carried along the left side of the fuselage through the bomb bay to a tee handle located on the aft side of the rear wing spar in the bomb bay. This handle when pulled operates the rotor cam opposite the release direction and closes the nut on the screw. The bomb doors can be closed by the radio operator by pulling on the nut closing cable and at the same time slowly turning the bomb door hand crank which is located directly opposite on the right side of the fuselage. This will engage the nut for normal operation of the doors.

3. Safety Controls

The bomber's controls are arranged so that the bomb racks cannot be operated until the bomb doors have been opened. This arrangement consists of a spring loaded plunger installed on the release handle so that the handle is locked in the forward position when the doors are closed. The plunger is connected by means of a cable to a slide lever installed on the bulkhead adjacent to the screw and split nut assembly. When the nut is moved to the lower end of the screw either by means of the crank handle or by emergency release, the lever is forced down retracting the plunger from the release handle and permitting the handle to be moved to the selective or salvo positions.

Electrical operation of the bomb racks with the bomber's release handle in the "Lock" position is likewise impossible because the solenoids plunger rods remain locked against the levers at each station until the release handle is moved to "Selective" position.

IMPORTANT. To prevent inadvertent release of the racks while loading bombs, the bomber's release handle should be placed in the "Lock" position after the desired stations have been cocked preparatory to loading.

H. Releasing Bombs

The following procedure should be followed when releasing bombs.

1. Open bomb doors with hand crank.
2. Set the release handle to "selective" position.
3. Set the arming handle to "arm."

5. Set the toggle switch to "select" or "train" as desired.
6. Release bombs in accordance with the instructions given in the data accompanying the type of bomb sight used.
7. After dropping bombs, return release handle to "lock" position.
8. Return arming handle to "safe" position.

Caution: Always return the arming handle to "safe" position except when actual bombing operations are made.

9. The bomber may make a "salvo" release by moving the release handle to "salvo" which will automatically release all stations, or by holding the "train" switch in the operating position until the racks are empty. These two operations cannot be accomplished unless the bomb doors are open. (See preceding paragraph.)
10. Emergency release of the bombs is accomplished by the pilot and/or radio operator only by pulling their emergency release handle as far as possible or approximately 7 inches.
11. To close doors after emergency operation, see paragraph G-2.

I. Maintenance

1. Adjustment of the Release System

To check the bomb rack release system proceed as follows:

a. Open bomb bay doors completely.
b. Place release handle in "selective" position.
c. Cock all stations.
d. Move the release handle to "salvo" which should release all stations simultaneously.
e. If this does not occur, the cables to the clutch should be adjusted by means of the turnbuckles until there is a 3/16 inch gap between the clutch cam and pin. See View E-E, Figure 56. The clutch cams can be seen with the aid of a mirror and flashlight.
f. Next place the release handle in the "selective" position again and recock all stations.
g. Move the release handle to the "lock" position.
h. It should not be possible to operate the racks by means of the electrical controls.
i. Check the position of the clutch pin and cam which should be in accordance with View F-F of Figure 56.
j. If the racks do not operate as noted above, the push rod system between the station levers and the clutch should be readjusted until the racks are synchronized for simultaneous release. It must be ascertained that the racks can be locked against selective release by means of the bomber's release handle after any adjustments are made.

2. General Maintenance

All parts of the bomb rack mechanism and controls should be inspected at regular periods depending upon its service use. The safety locking device on the release handle should be checked for proper functioning prior to daily operations when bombing equipment is being used. The operation of the racks should be checked at intervals to ascertain that they function properly.

Except for long periods when the bomb racks are not used, they should be kept free from grease or oil. Cleaning should be done with kerosene. See grease and oil chart, Appendix IV. Bearings may be oiled with thin lubricating oil to prevent corrosion.

Zerk fittings are provided on all gear boxes and hinge bearings of the bomb doors.

The vertical screw and parts of the split nut mechanism should be cleaned of accumulated dirt and grit and re-oiled in accordance with the grease specifications.

See Section XIX-A for functions of the electrical control mechanism.

J. External Bomb Racks

1. General

The equipment for carrying and releasing external bombs consists of the following:

2 Special Streamline Shackle assemblies, electrical and mechanical release (Removable Type)
1 Type B-3 Arming Handle
2 Type A-3 Emergency Release Handles (one each for the Bomber and the Pilot)
1 Type B-3 Handle for locking the external rack mechanism
1 Bomb Hoist Support (uses the two Type C-2 Hoist Units)
Bomb Load Indicator (incorporated with Switch panel)
Electric Release Switches (Bomber Only)

The following listed bombs can be carried on and released from each of the external racks.

1 bomb at 2000 lbs. (907.0 kg.), or
1 bomb at 1130 lbs. (512.5 kg.), or
1 bomb at 625 lbs. (283.5 kg.).

2. Description

The rack mechanism, Figure 60E, is of the toggle action type, that is, the levers are adjusted slightly off center so that the locking forces against the bomb hooks are multiplied when the mechanism is latched. Each rack is equipped with two sets of hooks for carrying three sizes of bombs. The small hooks are used for 600 lb. and 1100 lb. bombs; the large hooks for 2000 lb. bombs. These hooks are interconnected by means of push rods and links so that they open together as shown in Figure 60E. When bombs are released, the hooks are moved through the center locking position, and the weight of the bomb completes the operation of the release mechanism.

The rack mechanism is so arranged that the bomb hooks cannot be latched without first cocking the electrical solenoid. Cocking the solenoid is accomplished by first retracting the spring loaded rack locking pin by moving the lock control handle in the bomber's compartment forward to the "Armed" position. Second, raise the solenoid cocking lever, located on the left rear end of the rack, until the trigger arm is set on the solenoid trip lever. Raising the cocking lever requires considerable force to compress the long release rod compression spring at the rear of the rack. The bomber's locking handle should be returned to the "SAFE" or aft position before loading the rack to prevent inadvertent electric release of the rack.

Cocking the solenoid does not affect the bomb hook leverage because the connection between the solenoid and bomb hooks is equipped with a "dog" that operates in the forward direction only to release the bomb hook locks. Releasing the rack mechanically will not trip the solenoid mechanism but it is recommended that the solenoid be checked for "latched" after each release of the rack.

After cocking the solenoid, the bomb hooks can be closed by means of two "Tee" handle cocking rods provided at the forward end of the rack. When closing either set of bomb hooks, the small hooks must be closed first. When carrying 2000 lb. bombs, both sets of hooks must be closed. However, it is important that the 2000 lb. hooks be left open when 600 or 1100 lb. bombs are carried. This is done to permit the release system to operate directly on the small toggle bar locking hooks which requires greater forces to release due to the short leverage, and therefore any possible lost motion in the system will not be absorbed in releasing the large hook toggle bar.

The small hooks are closed by first striking the 600 - 1100 lb. tee handle, and then sharply pulling it forward. This raises the small toggle bar, and latches the toggle bar lock hooks over the pins on the bar. A latch locking lever is provided on the right side of the rack to completely latch the toggle hooks if the forward pull of the tee handle was not sufficient. This latch lever must indicate closed before the 2000 lb. hooks can be latched.

The large bomb hooks are closed by pulling the 2000 lb. tee handle sharply forward to raise the large toggle bar into position where the toggle hooks can be engaged by means of the large latching lever on the right side of the rack.

When the bomb hooks are completely latched, the linkage between the toggle bar lock hooks and the solenoid release rod lever is rigid at the "dog." Mechanical release of the rack is accomplished either by means of the bomber's or pilot's Type A-3 emergency release handle which operates the rack release rod pulling the toggle hook linkage free from the dog. Electrical release is accomplished by energizing the solenoid which retracts the solenoid trip lever and frees the trigger. The solenoid release rod is then actuated by the compression spring and the toggle bar hooks released through the "dog."

The arming system in this rack is shown in Figure 60E. It consists of a wire keeper and spring loaded wire retaining lever which may be locked shut by means of a push rod and latch. The retaining lever extends out of the bomb rack to provide a grip for moving it out of the keeper to permit inserting the arming wire. The light spring which holds the lever in the keeper is not strong enough to retain the wire if the rack is not armed. Arming is accomplished by moving the arming rod AFT which locks the lever system shut as shown in the Figure 60E. If armed, the wire is retained in the keeper and withdrawn from the bomb fuses when the bomb is released.

The bomb rack is equipped with three sets of cast aluminum alloy steady braces used to eliminate lateral swaying of the bomb. See Figure 60D. A spring arrangement in each brace causes the brace to be pulled down and swung back against the rack when the bomb is released, thus reducing wind resistance.

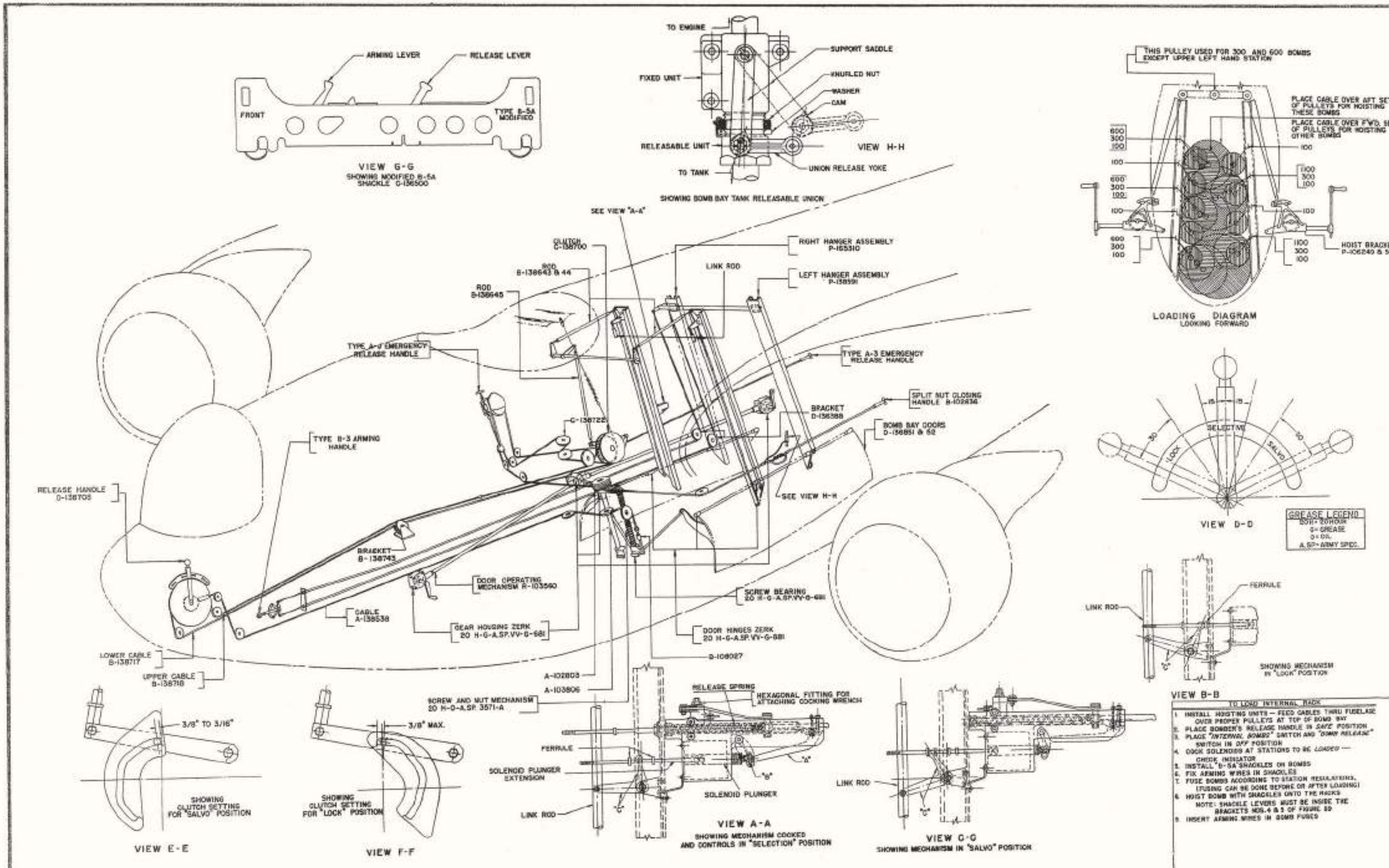
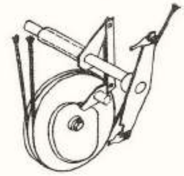


FIGURE 56 RELEASE MECHANISM DIAGRAM FOR THE ELECTRICAL BOMB RACK

TO LOAD EXTERNAL RACKS

1. REMOVE NOSE FAIRING
2. DISCONNECT ELECTRICAL CIRCUIT TO SOLENOIDS
3. INSTALL EXTERNAL BOMB HOIST
4. MOVE BOMBER'S RACK LOCKING HANDLE *FORWARD* OR "ARM"
5. COCK SOLENOIDS BY PUSHING COCKING HANDLES *UP*
6. MOVE RACK LOCKING HANDLE *AFT* OR "SAFE" TO PREVENT INADVERTANT ELECTRICAL RELEASE
7. CHECK LEVER RELEASE MECHANISM (VIEW I-I) FOR LOCKED POSITION BY PULLING DOWN *BOTH* STOP CABLES ACCESSIBLE FROM BOMB BAY
8. *PULL* RELEASE ROD AT RACK *FORWARD*
9. *PUSH* LATCHING HANDLE (FOR SIZE HOOK TO BE USED) *AFT*
10. HOIST BOMB INTO POSITION
11. *PULL* 1100-600 LB HANDLE *FORWARD* FIRST
12. *PULL* 2000 LB HANDLE SECOND
13. SET 1100-600 LB LATCH INDICATOR (RIGHT SIDE OF RACK) TO THE LATCHED POSITION
14. SET 2000 LB LATCH INDICATOR TO LATCHED POSITION
15. CHECK POSITION OF RACK MECHANISM LATCH FOR *COMPLETE* LOCKED BEFORE RELEASING SUPPORT OF BOMB
16. REMOVE HOISTING EQUIPMENT
17. *CONNECT CONDUIT*
18. REPLACE NOSE FAIRING
19. ADJUST SWAY BRACES TO BOMB *DO NOT OVERTIGHTEN BOLTS*



VIEW I-I

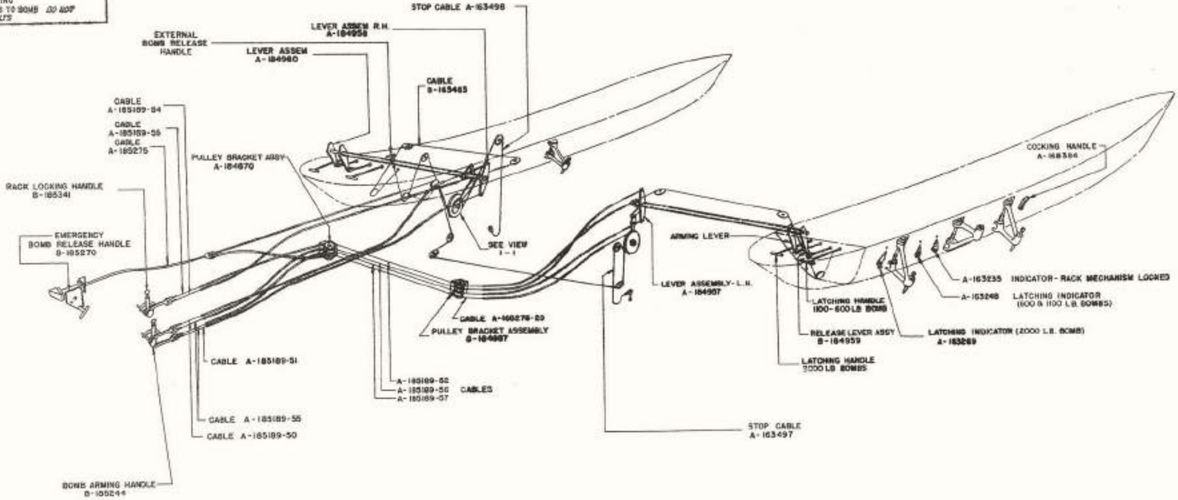


FIGURE 56-A RELEASE MECHANISM DIAGRAM FOR THE ELECTRICAL BOMB RACK

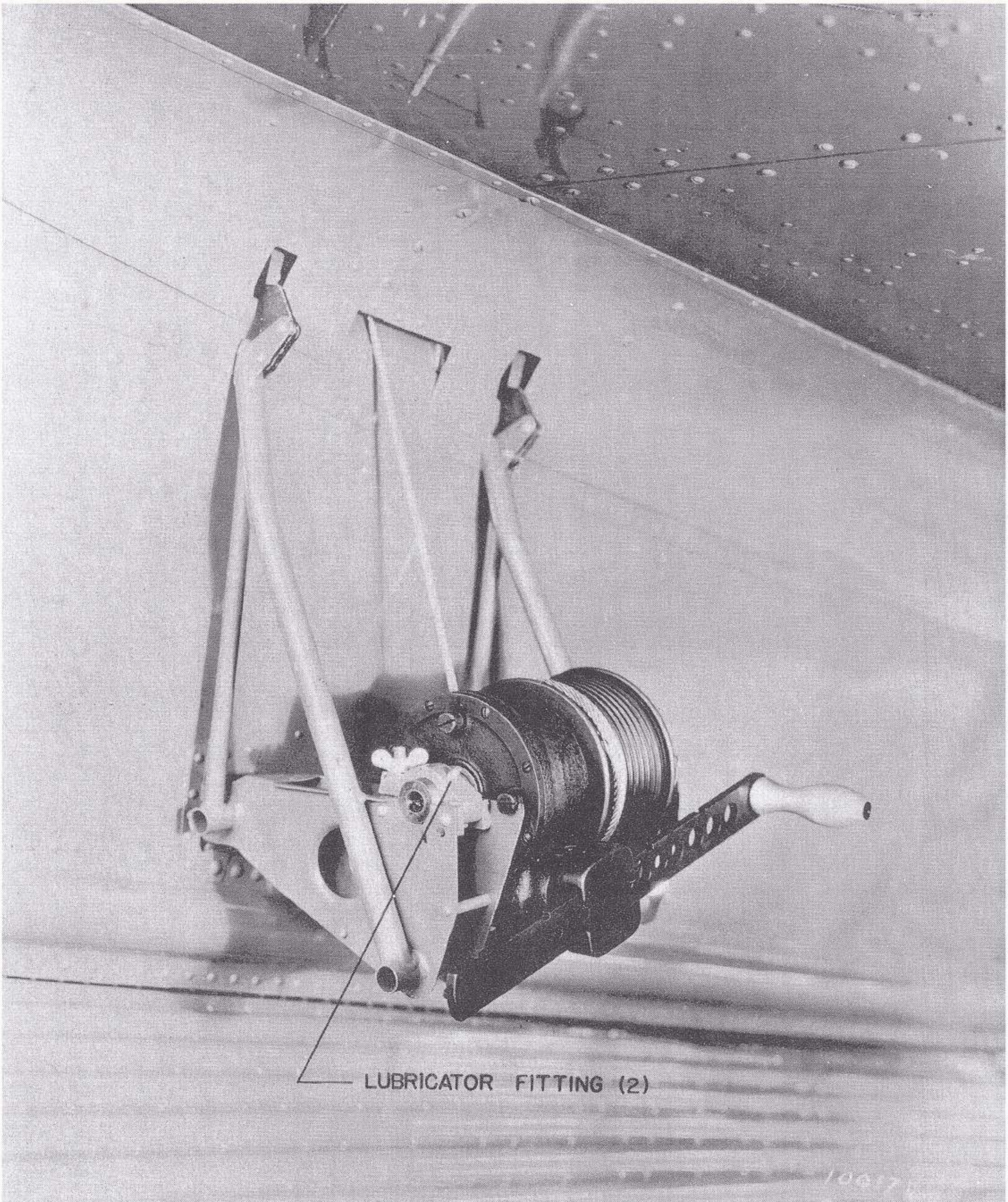


FIGURE 57 TYPE C-2 BOMB HOIST READY FOR USE

K. External Bomb Hoist

1. General

A portable bomb hoist shown in Figure 60C is provided for lifting the bombs onto the racks. This hoist consists of a tubular support equipped at the upper end with a cast fitting for attaching it to the bomb rack, and at the lower end with a cast support bracket for mounting the same Type C-2 hoist drums used with the internal bomb racks.

It is necessary to remove the nose fairing from the rack and to disconnect the solenoid cable at the plug to install the hoist. Hooks are provided on the front end of the rack over which the hoist is installed and pinned to a lug adjacent to the support tube.

The hoist assembly without drums may be stowed in the tail of the fuselage behind the flare racks as shown in Figure 60B. The flare tubes may be lowered to permit access to the stowage brackets.

2. Hoisting Bombs

Procedure for hoisting bombs is as follows:

(a) Install the C-2 hoist drums on the tubular support and insert the cables in the pulleys. The drums should be installed with the grooves outboard and the handle axis horizontal when on the airplane. See Figure 60C.

(b) Install the pulley brackets shown attached to the sides of the bomb rack in Figure 60C in the proper position as indicated by the nameplates on the rack. Note: One position is provided for the 2000 pound bomb and the other position for the 1100 and 600 pound bombs.

(c) Provide the proper hoisting sling for the bomb to be lifted and put in place, tightening the lift cables enough to check the balance of the bomb in the sling.

(d) Hoist the bomb into position and latch to the bomb rack by pulling on the proper latching handle indicated by the nameplates on the front end of the rack. Make sure that the mechanism is completely closed by striking the release lever with the hand. Check the three indicators provided on each side of the rack to make sure that all hooks are properly functioning.

L. Adjustment of the Release System

A nameplate is provided on the inside of the bomb rack indicating the movement of the arm and safe mechanism. The controls should be adjusted to give this movement.

The push rods in the external rack should be adjusted so that the bomb hooks are completely latched when the bomb rack is cocked. A check for this condition is had by observing the position of the three indicators located on either side of the rack. When properly adjusted all three indicators should coincide with the adjacent pointers at the same time.

The cable system operating the release cams inside the pilot's cockpit will be properly adjusted when the notch provided in the cam on each release is seated against the follower pin on the tripping lever. See View I-I, Figure 56A. In this condition the cables connecting the operating handles should be drawn up snug but not enough to start the release action through vibration. The proper operation of the release system can be checked by hanging 200 pounds total on the small hooks and pulling the release, or by hanging 300 pounds total on the large hooks and operating the release system. If the entire system is functioning properly the weights will be released.

Important: This rack releases by the weight of the bomb and a bomb weighing less than 500 pounds should never be carried on the large hooks or a bomb weighing less than 400 pounds should never be carried on the small hooks.

M. Maintenance

Ball bearings, pre-packed with grease are used throughout the bomb rack controls except in the nose section of the wing. The micarta bearings on the torque tubes in the wings should be oiled occasionally. All cables should be coated with a suitable rust preventative especially where they pass through fairleads and chafing strips. Graphite grease should be applied to the cables at these points.

The external racks are fitted with "Olite" bronze bearings which require no further lubrication. The internal racks however should be kept well lubricated as required with excess oil or grease wiped off to minimize the accumulation of dirt.

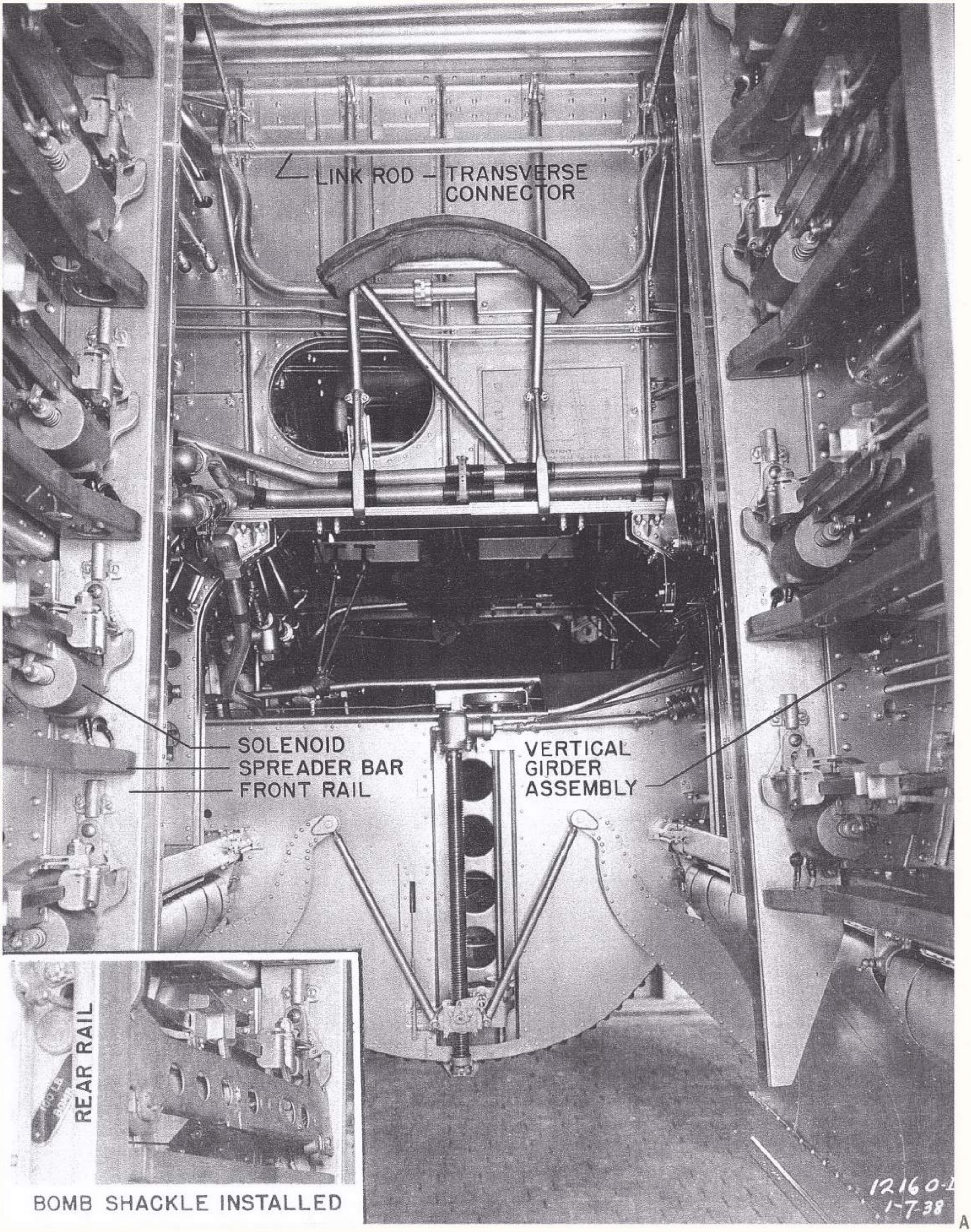


FIGURE 58 BOMB RACK INSTALLATION - BOMB BAY LOOKING FORWARD

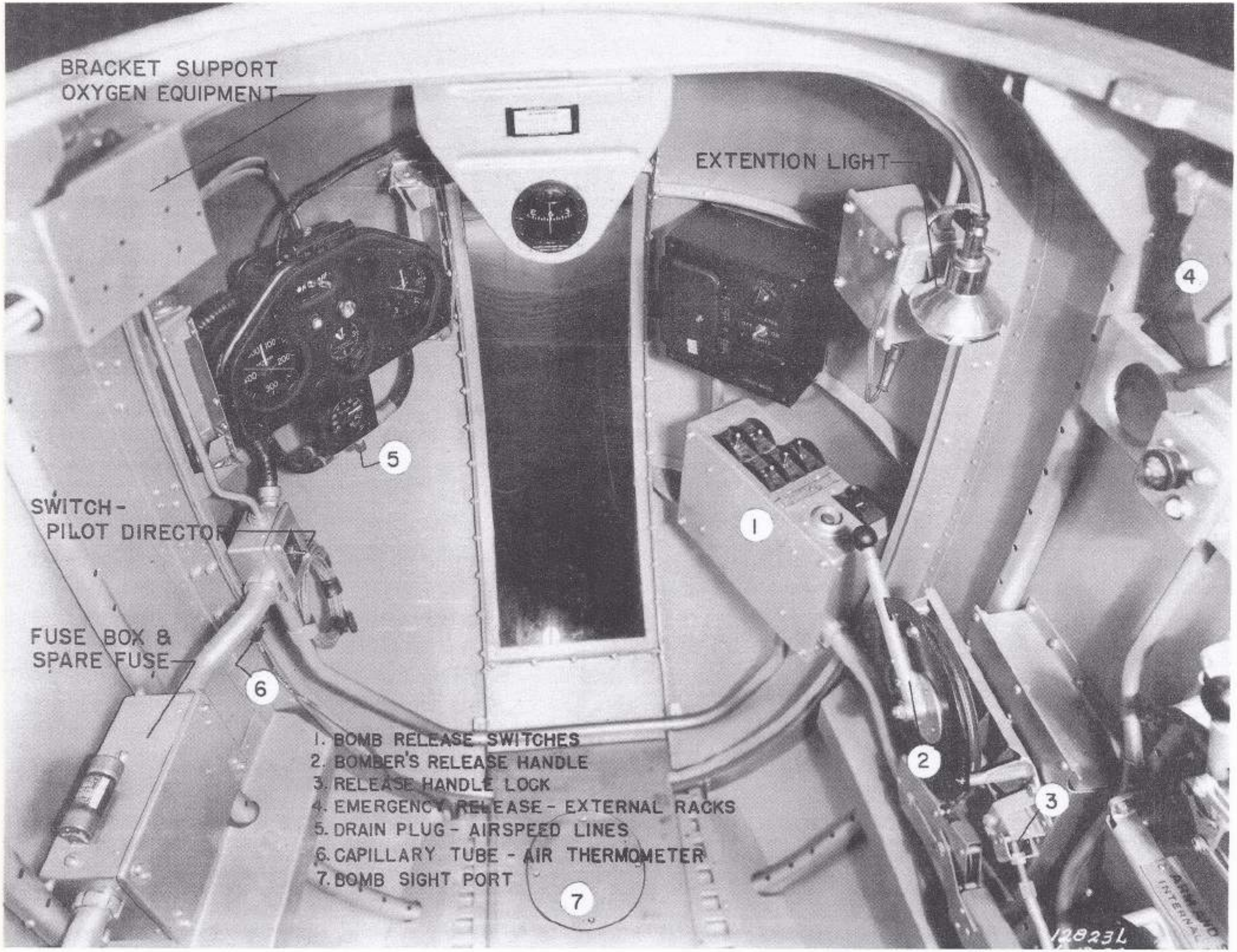


FIGURE 60 BOMBER'S COMPARTMENT - LOOKING FORWARD

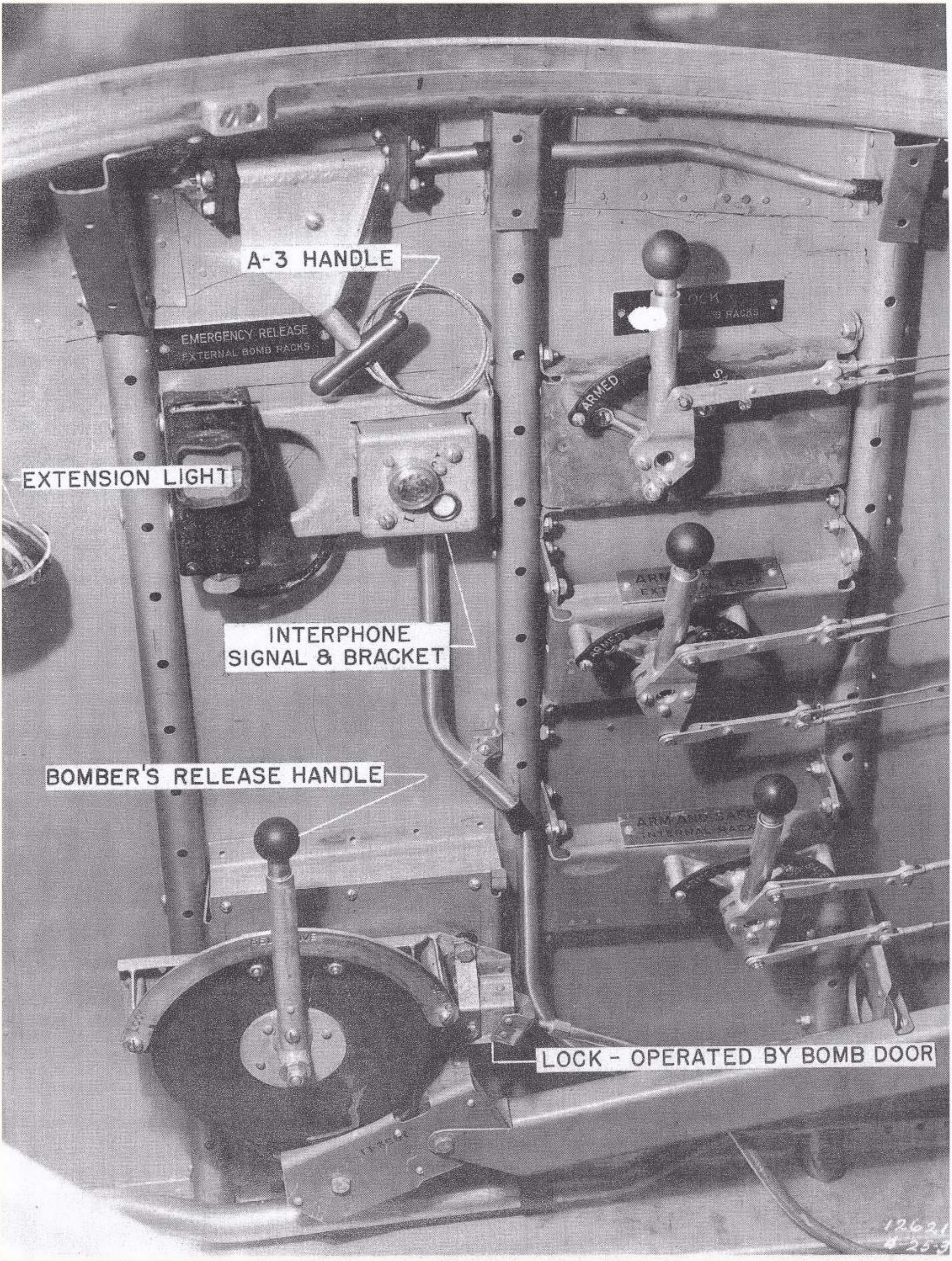
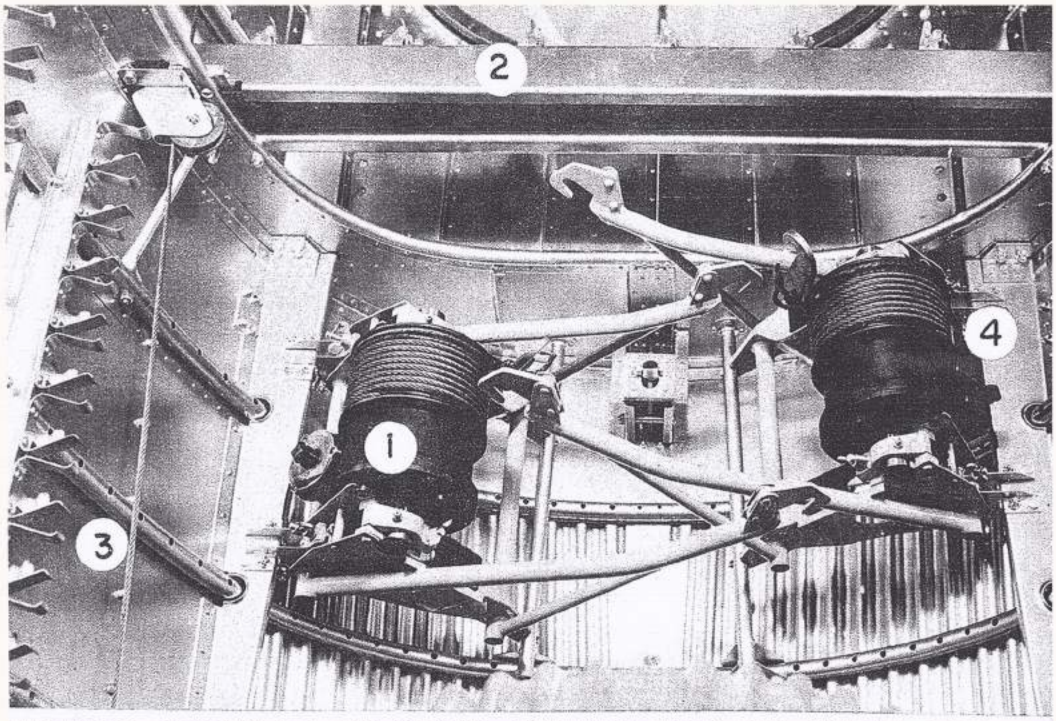


FIGURE 60A MANUAL CONTROLS - BOMBER'S COMPARTMENT C



1. LEFT HOIST ASSEMBLY (TYPE C-2)
2. CLIPS-AMMUNITION BOXES
3. SIGNAL CARTRIDGE CLIPS
4. RIGHT HOIST ASSEMBLY (TYPE C-2)
5. EXTERNAL HOIST ASSY.
6. FLARE RACKS (TYPE A-3)
   NOTE: LOWER THE FLARE TUBES TO THE POSITION SHOWN TO STOW THE EXTERNAL HOIST
7. BRACKET-FLARE RACK RETAINER
8. BRACE ROD - DOOR SUPPORT
9. LATCH-FLARE RACK RELEASE

INSERT: STOWAGE OF BOMB HOISTS-TOP OF FUSELAGE

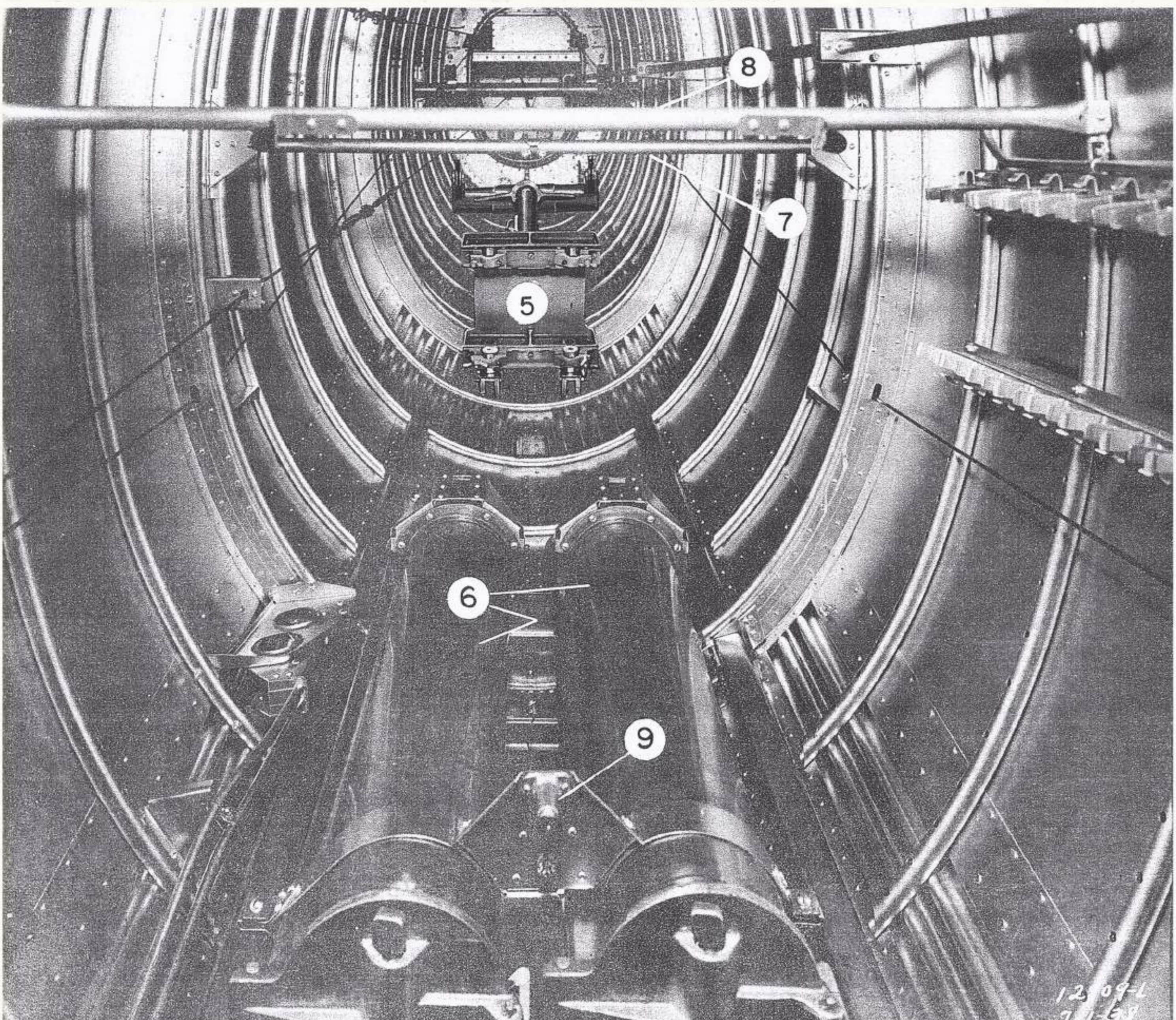


FIGURE 60B STOWAGE OF BOMB HOIST EQUIPMENT

C

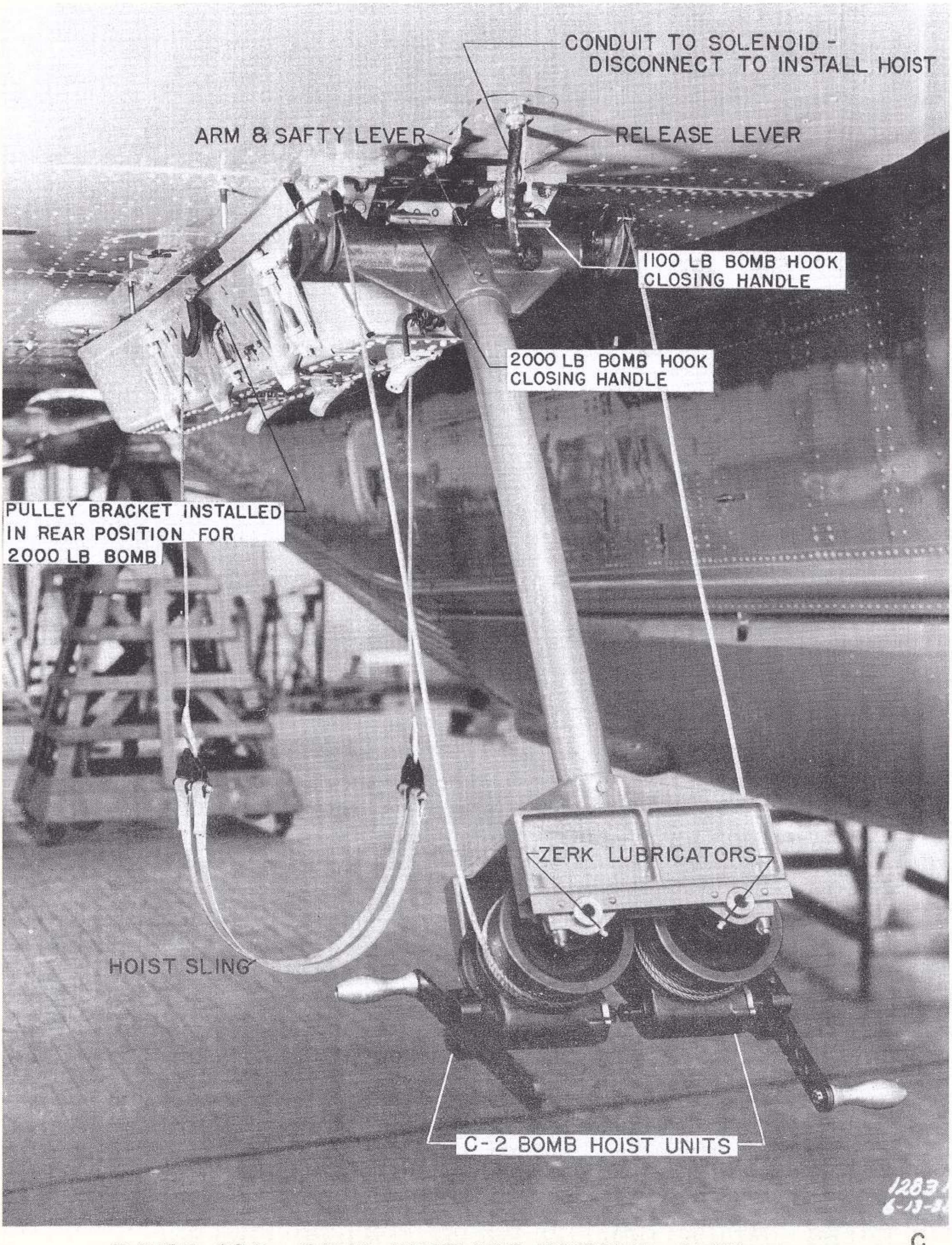


FIGURE 60C BOMB HOIST FOR EXTERNAL RACK

C

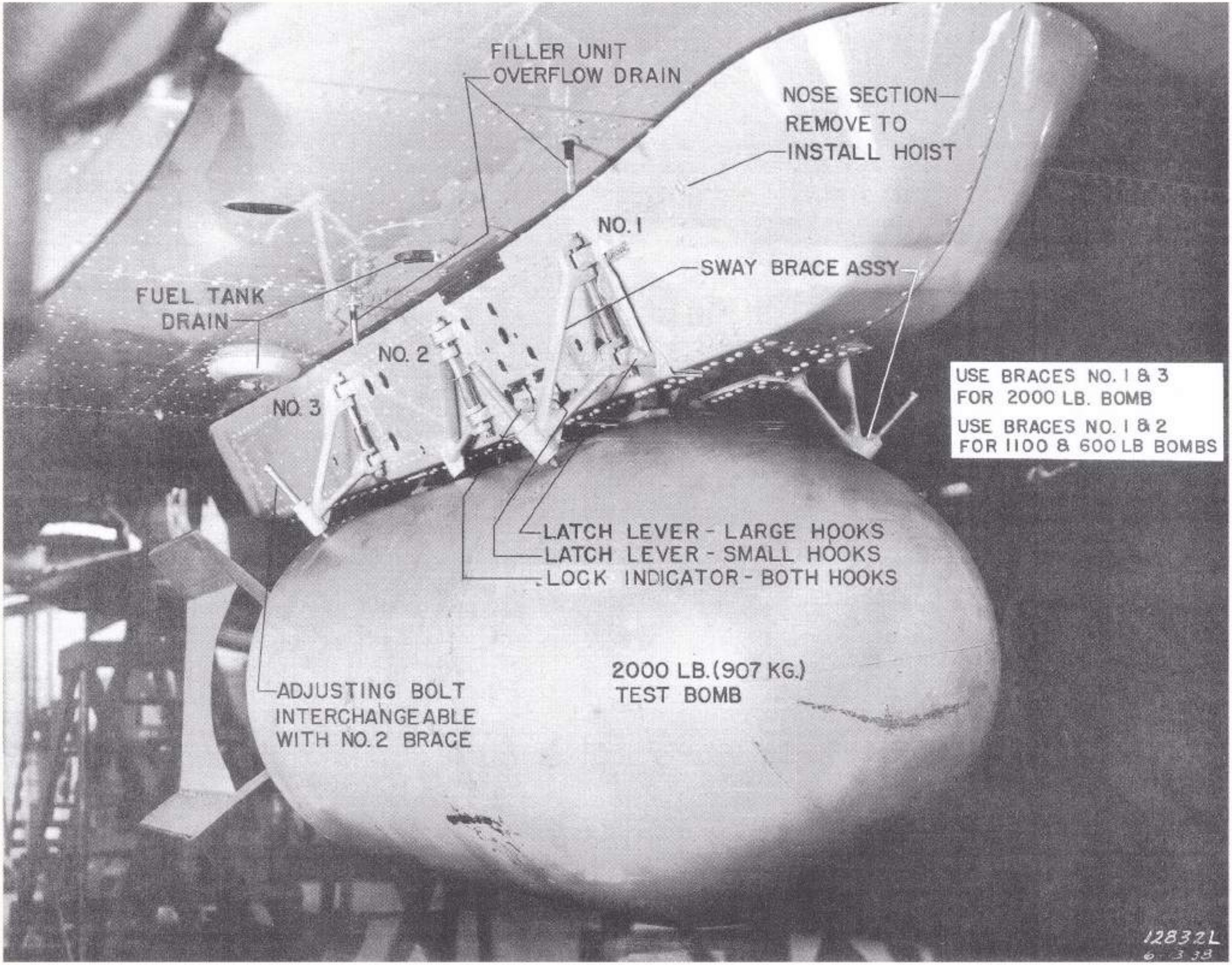


FIGURE 60-D 2000 LB BOMB INSTALLATION IN EXTERNAL RACK

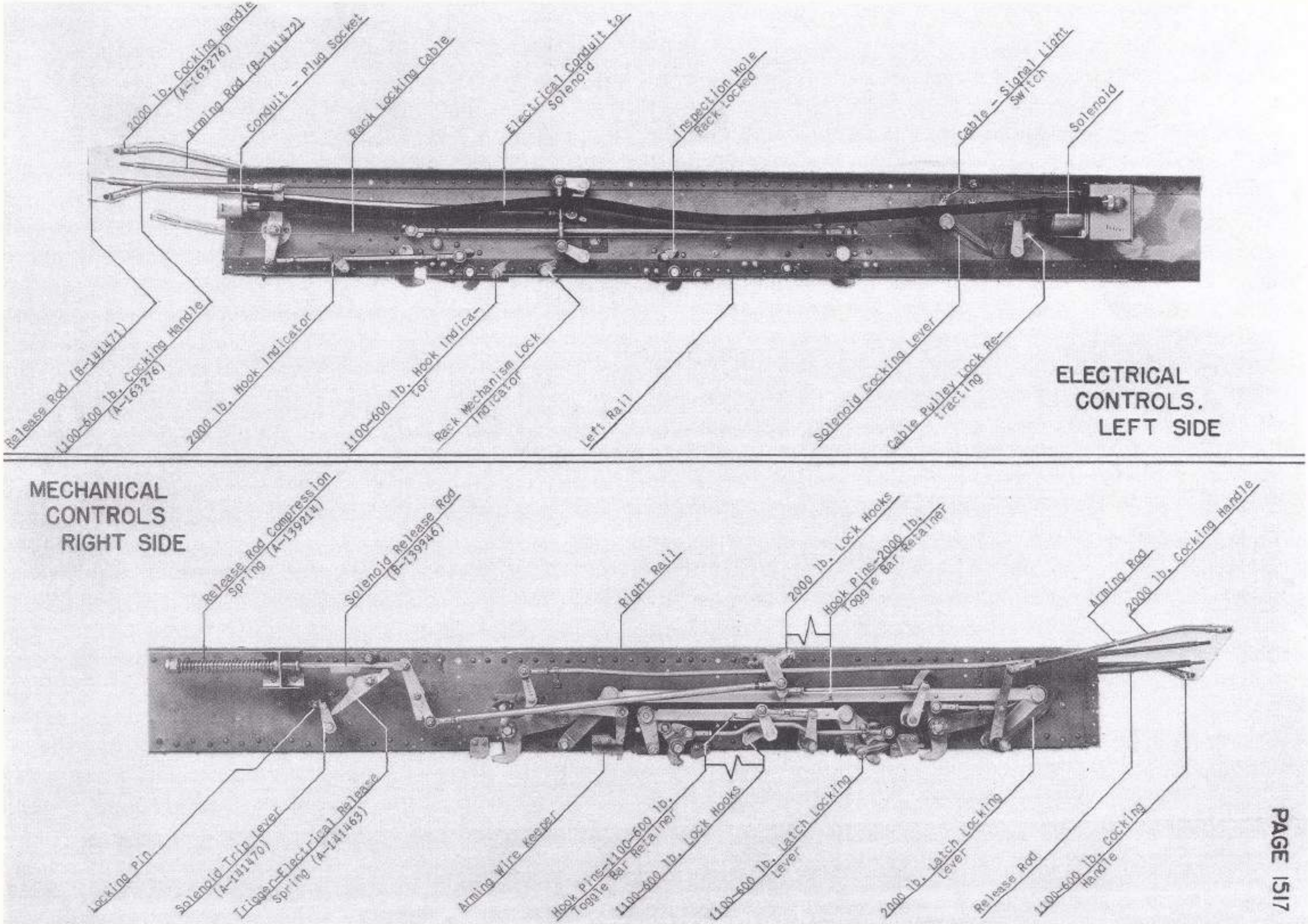


FIGURE 60-E EXTERNAL BOMB RACK RELEASE MECHANISM

SECTION XVI

MACHINE GUN INSTALLATION

A. Description

The Colt MG-40 machine gun installations for these airplanes consists of three .303 Caliber Flexible Machine Guns, one installed in the nose turret, one in the rear cockpit, and one in the bottom of the rear section of the fuselage aft of the rear cockpit.

The guns are manufactured by the Colt's Patent Fire Arms Mfg. Company, Hartford, Conn., and complete instructions for the installation, operation, and maintenance are given in the Handbook furnished with each gun. Complete facilities are provided in the airplane for the operation of the machine guns, and for carrying reserve quantities of ammunition.

B. Nose Gun Turret

The forward gun is installed in a rotating turret located in the nose of the fuselage. The turret is constructed of aluminum alloy formed channels rigidly riveted together to form a dome type frame with the channel ends secured to a circular ring at the base. The entire structure is fitted with clear moulded Plastacele windows which are held in place between the flanges of the frame channels and outer cover strips by means of counter-sunk-head screws and self-locking nuts. This construction provides for readily replacing the plastacele when necessary. The turret is provided with a vertical slot equipped with stainless steel tracks on which the gun carriage is mounted The turret is secured by means of rollers to a steel track which forms a permanent part of the fuselage structure, and provisions are made for rotating the turret through a complete circle.

The turret can be locked at intervals around the ring by means of a spring-loaded pin located at the base of the vertical slot, and operated through a steel cable attached to a trigger mechanism on the gun carriage. Stops are installed on the base ring to limit the normal rotation of the turret in either direction in order to prevent the gunner from firing into the propellers and wings. The turret can be rotated past these stops by lifting the stop lever which is hinged to the base of the turret frame at the gunner's left.

The machine gun is mounted on a special carriage (Figure 62) which is retained on the vertical track in the turret by rollers. Holes are provided at two-inch increments in the sides of the tracks to engage the locking pins in the gun mount. The levers at the handle of the gun mount control the locking pins, both for the turret and for the mount; the top lever being used for the turret lock, and the bottom lever for the mount lock. These levers can be operated separately, or simultaneously as desired.

When the gun is installed, its weight is balanced by two elastic cords which are anchored to the turret frame aft of the gunner and carried in channels around the dome of the turret to attach at the top of the gun mount. Care must be exercised when releasing the gun mount from a position at the bottom of the vertical track that the handle is held firmly to prevent the mount from raising up too suddenly.

When not in use, the turret is rotated either way and locked with the vertical gun slot facing aft. When the machine gun is in place, but not in use, it is stowed by lifting the gun to the extreme "up" position, and then rotating the turret until the gun points upward over the top of the fuselage and the turret is locked in that position.

The gun mount can be removed from the vertical track by disassembling the roller toggles from the mount. These toggles are attached with steel clevis bolts which are tapped into the toggles. The balance cords must also be detached at the rear when removing the mount. The turret lock cable passes through the actuating mechanism of the gun mount and is attached to the turret near the upper end of the vertical track and must also be disconnected when removing the gun mount. After the bolt holding the lower forward end of the right hand balance cord is removed, the mount can be lowered to the bottom of the track and turned to free the cable-actuation lever on the left hand side.

The entire turret is removed by taking out the clevis bolts that secure the attaching rollers to the inner periphery of the turret base ring. These bolts are located around the outer periphery of the ring, and may be reached from outside the airplane, or from within the nose section.

The nose gunner is provided with a swing seat attached to the sides of the turret at right angles to the gun. An elastic shock cord pulls the seat up out of the way when not in use. Provisions are made to stow six ammunition magazines on the fuselage aft of the gunner for the ammunition.

C. Rear Upper Gun Installation

The upper rear machine gun is mounted on a special carriage, on a semi-circular track which extends around the sides and aft end of the gunner's cockpit. The gun carriage is equipped with ball bearing rollers that secure it to the track and assure smooth operation. A clamp type latch in the carriage is operated by the handle hinged at the sides of the carriage housing. Raising the handle releases the clamp on the track and permits the carriage to be moved to any other position. See Figure 64C.

The carriage is equipped with a chuck-type, ball bearing lock mounting post in which the gun mounting bracket is inserted. (See Figure 63.) A locking pin is installed on the right side of the carriage yoke which permits the mounting post to be secured in three different positions. When not in use, the gun is stowed below the collapsible section of the rear enclosure in a special friction latch which is located directly forward of the enclosure on the right side of the airplane. The gun carriage must be moved forward on the track to raise or lower the enclosure, then moved back to the painted portion of the track which indicates the stowage position of the gun. To stow the gun, release the side locking pin and lower the gun cradle until the front mounting bolt engages the latch.

A safety release device is clamped to the copilot's control column to release the gun carriage and move it back if the carriage is left clamped to the forward right side of the track, and the column locked to the main controls. A latch and hook are provided for securing the rear section of the enclosure in the folded condition during flight and thus increase the clearance under the gun. Provision is made directly below the cockpit coaming for carrying six ammunition magazines. Steps are installed at each side of the fuselage to permit greater range when operating this gun.

D. Rear Floor Gun Installation

The Rear Floor Gun is installed in a chuck-type, ball-bearing lock, mounting post which is installed in an adjustable bracket located in the bottom of the fuselage (See Figure 64). Three positions for adjustment of the bracket are provided. The extreme aft position permits the gun to be swung out of the fuselage and pointed slightly toward the front.

This gun is operated through a door installed in the fuselage bottom, and hinged at the rear end so that it can be opened inward. A latch handle at the front end of the door is operable from the inside only. A cross bar installed above the door in the fuselage is equipped with spring latches for holding the door in the "UP" position.

When not in use, the gun is stowed using a latch (for the barrel) located on the right side of the fuselage. Provisions for carrying six ammunition magazines for this gun are made on the sides of the fuselage. A safety belt attachment fitting is provided in the floor aft of the gunner when he is in position.

E. Sights

The Wind Vane Sights furnished with machine guns should be used on all three installations. However, the Ring Sight on the front gun must be replaced with a special Martin Ring Sight that is furnished with the airplane. This is necessary because of the interference that exists between the standard ring sight and the turret gun track. This special ring sight is designed to be attached to the gun behind the feedway cover. It should be located 31-3/16 inches (79 cm) aft of the head on the wind vane sight.

F. Maintenance

The nose turret gun mount should be greased at the Zerk fitting every 40-hour inspection period, using grease, A.C. Spec. VV-G-681. The latches on the rear gun mounts should be oiled at this period with oil (A.C. Spec. 2-91). Oil or grease should not be applied to other parts of the gun turrets and release mechanisms unless the airplane is to be stored for an extended period. Dirt accumulation is otherwise likely to cause malfunctioning of this equipment.

The Plastacele windows in the turret and cockpit enclosure may be cleaned as described in Section XVI. When Plastacele panels are replaced, care should be exercised that the new holes match the screw holes in the metal, and that they are drilled #4 (.209") diameter in the Plastacele. IMPORTANT: After the attaching screws through the Plastacele are replaced and tightened, they should be loosened one turn. The loosened screws and the oversize holes through the Plastacele allow for expansion and contraction due to temperature changes.

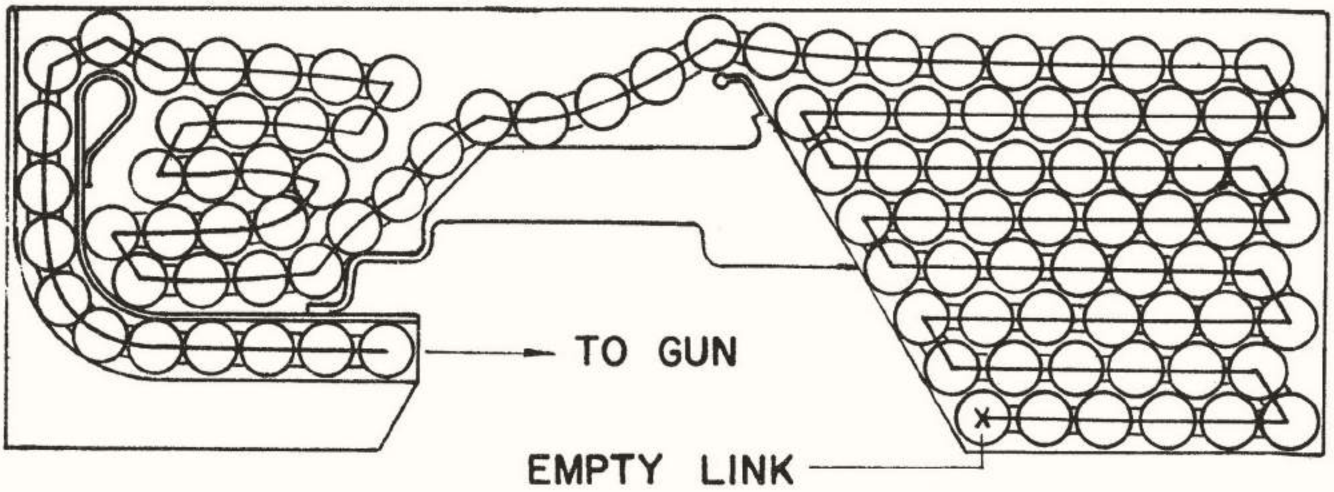


FIGURE 61 MODEL 139-W
LOADING DIAGRAM - AMMUNITION MAGAZINE
FOR REAR GUN

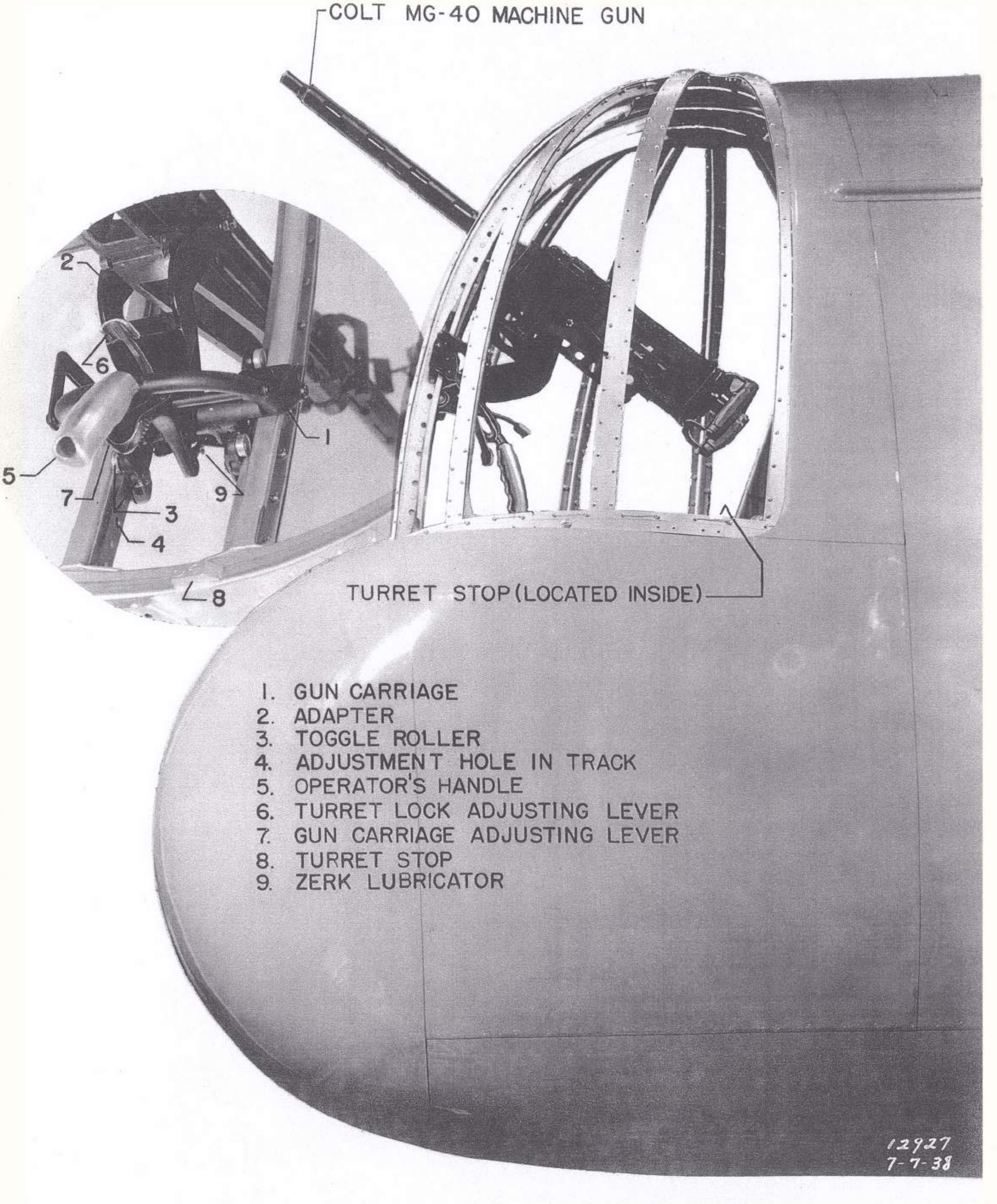


FIGURE 62 NOSE TURRET AND MACHINE GUN INSTALLATION C

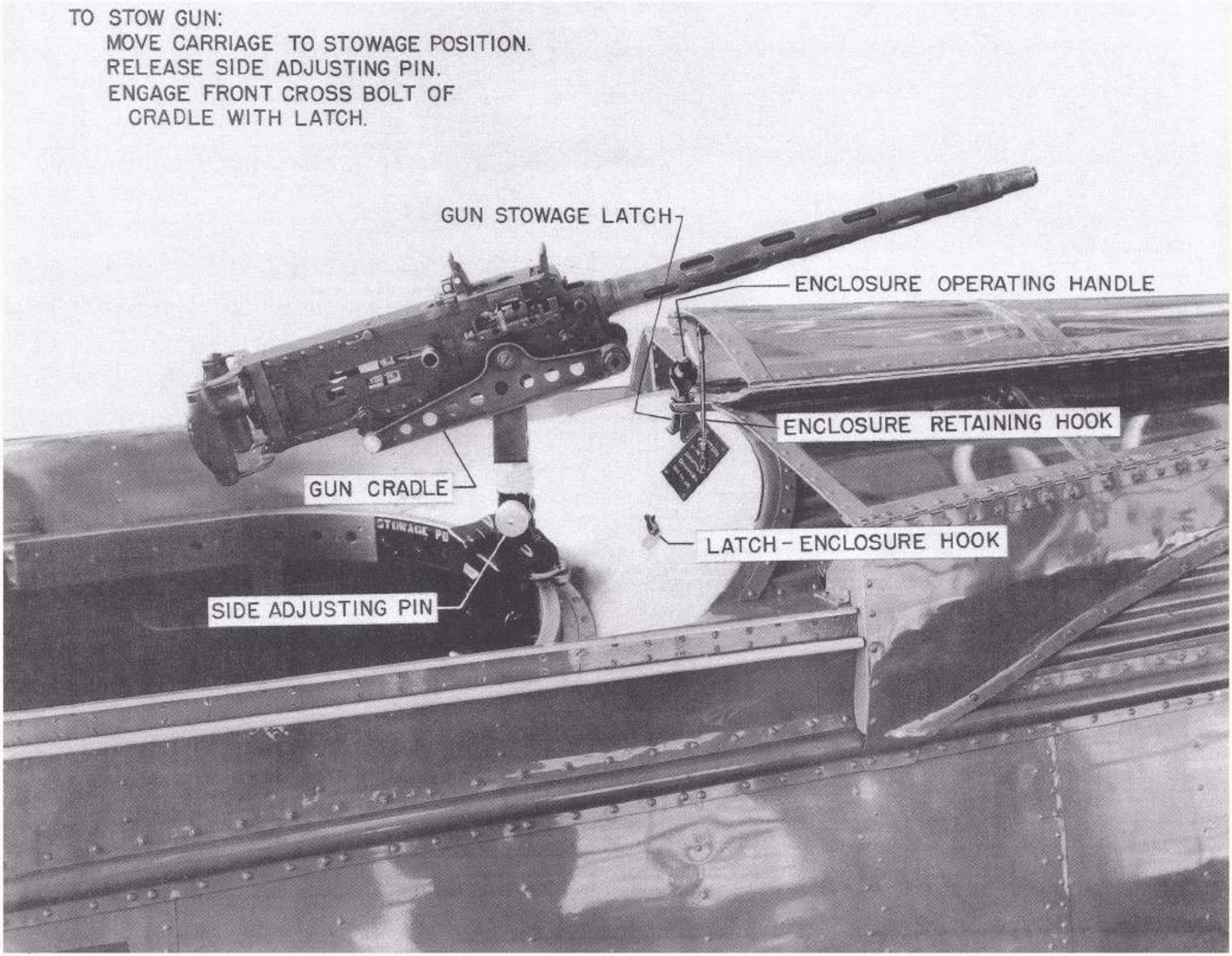


FIGURE 63 UPPER REAR MACHINE GUN INSTALLATION

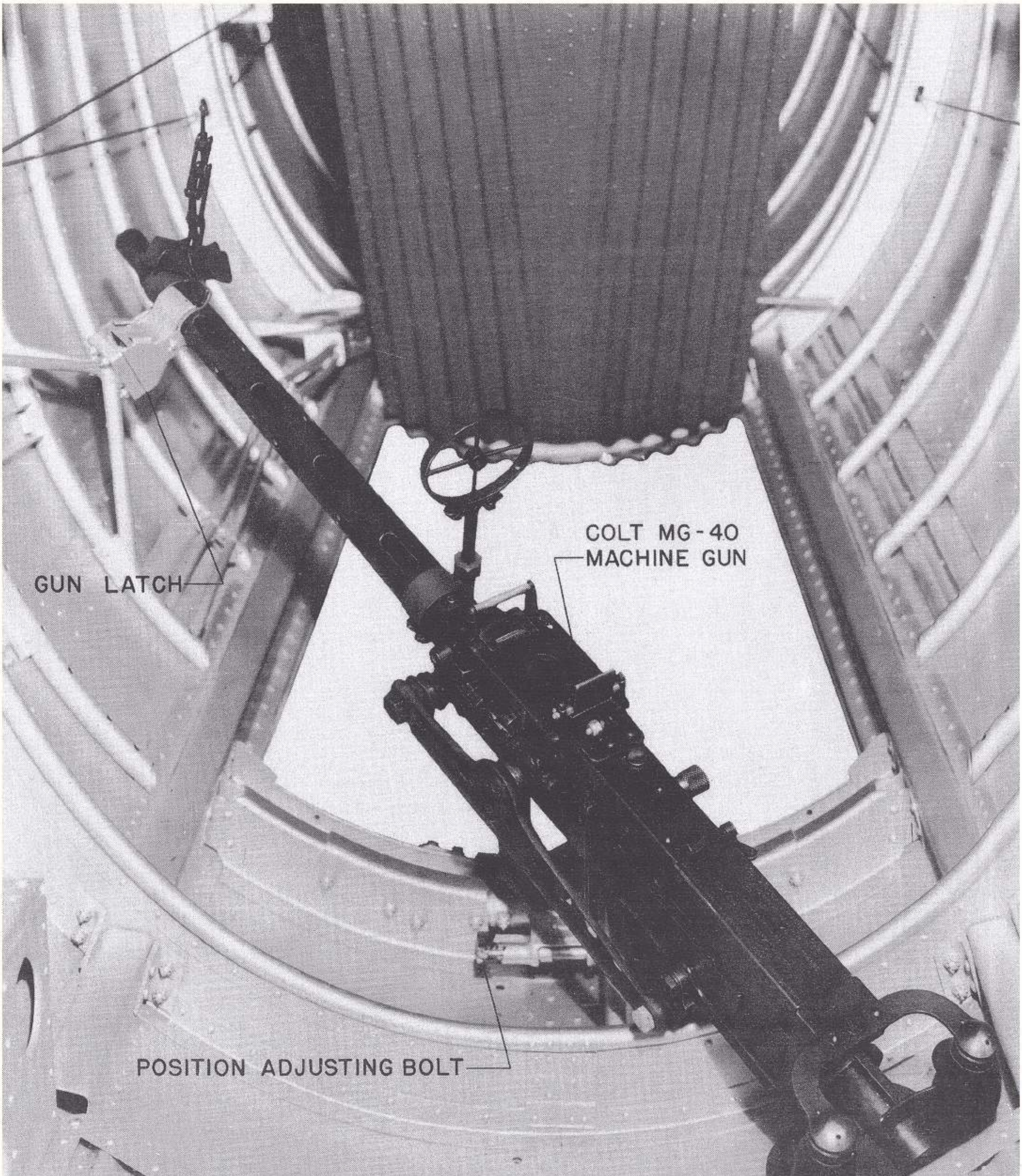


FIGURE 64 LOWER REAR GUN INSTALLATION

C

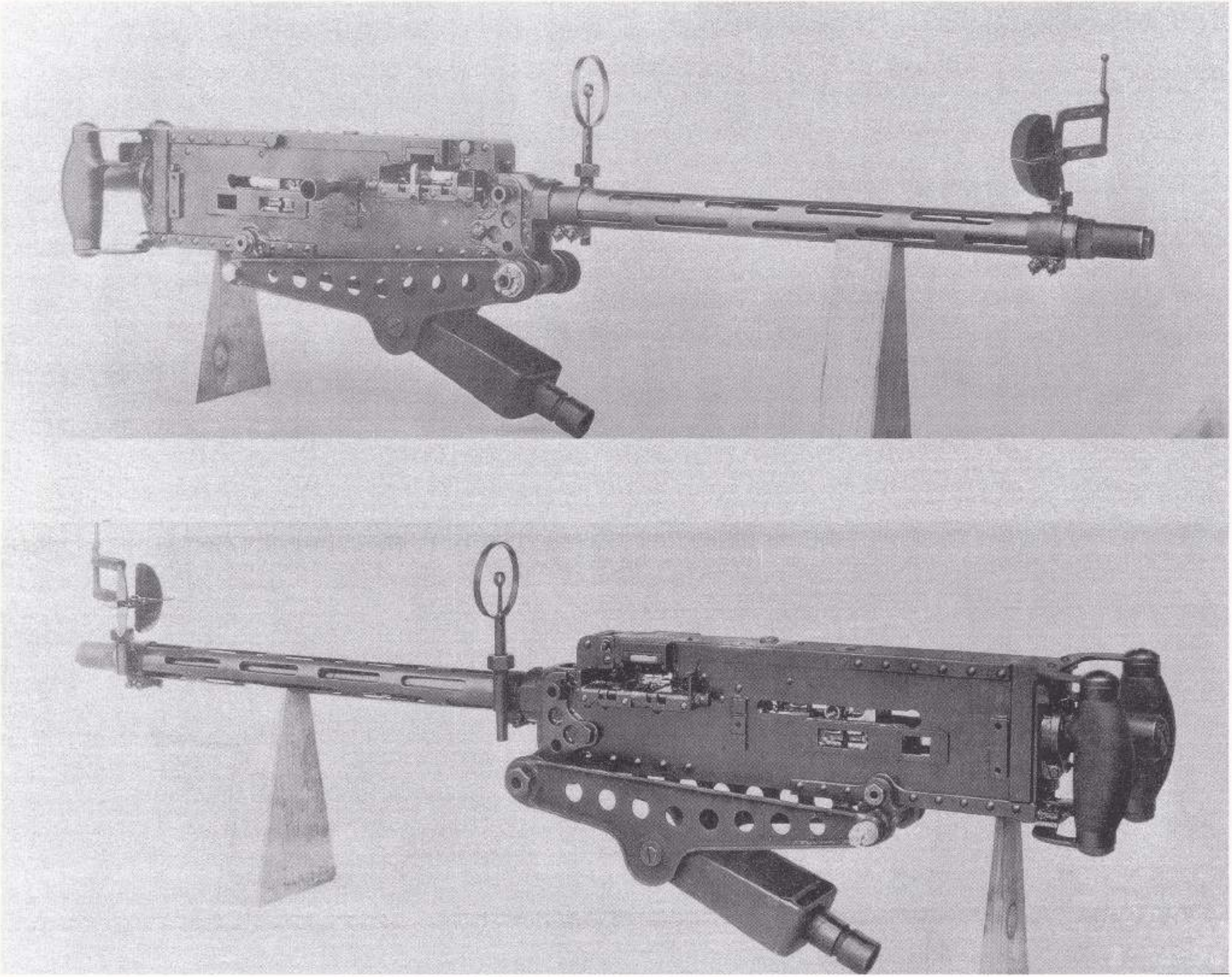


FIGURE 64-A   COLT M.G.-40 GUN WITH ADAPTOR

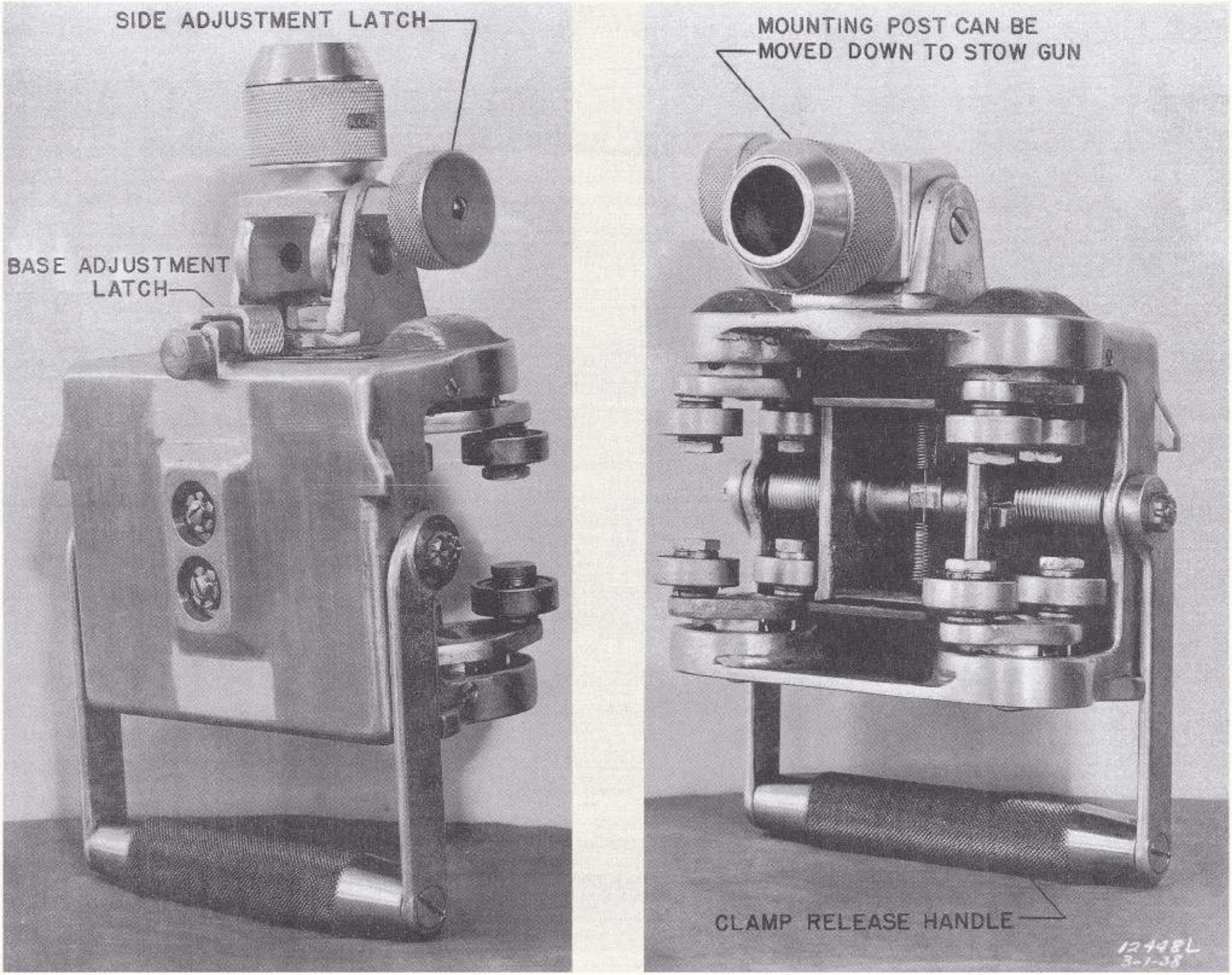


FIGURE 64-C UPPER REAR MACHINE GUN CARRIAGE - TYPE G-1

SECTION XVII

PYROTECHNICS

A. General

Space is provided in all Model 139-W airplanes for the installation of complete pyrotechnic equipment. The basic operating equipment is optional with the users of these airplanes. Complete equipment when installed consists of two Type A-3 racks and control for carrying and releasing Type A-8 parachute landing flares; friction spring type stowage clips for carrying both parachute and meteor type signal cartridges; and a Mark I signal flare pistol with a stowage bracket for the pistol.

B. Parachute Flares

Release controls for the Type A-8 parachute flares are provided for the pilot only. The flare releases are operated by means of 1/16 diameter extra flexible cables carried along the right side of the fuselage in Bowden casings and connected to two Type A-3 pull handles located below the landing gear controls in the cockpit.

The Type A-3 racks are installed in the rear of the fuselage aft of the floor gun door, (Figure 52). The racks are mounted on a hinge bracket, and are held in a vertical position by means of a latch at the top. When unlatched, the racks may be tilted forward to permit loading (Figure 60B). A hinged door, mounted directly on the bottom of each rack, is held in the closed position by means of a spring latching device which is sufficiently strong to support the flares. The latches are operated by means of the cables previously described. In the vertical position the racks are directly above the reinforced well in the bottom of the fuselage which should be kept clean to assure proper functioning of the doors.

Before loading the flares into the racks, the tear strip at the top should be pulled off and the flare cover removed to expose the retainer wire. The cover should be disposed of. The flares are installed from within the fuselage by tilting the racks forward and carefully inserting the flares until they rest on the doors. The retainer wire should then be attached to a plunger provided in the rack cover which is then latched closed.

Additional information on these flares is contained in the pamphlet published by the Pioneer Instrument Company.

C. Maintenance

The flare racks and cable installation should be inspected and operated at each twenty hour period. All dirt must be cleaned from the doors and the cables inspected for wear.

Important: Oil or grease should not be used at any point in the cable system or on any part of the flare rack mechanism, as the accumulation of dust and dirt may cause malfunctioning in an emergency. Clean with a suitable solvent to prevent rust and corrosion.

D. Signal Flares (For Airplanes Equipped with Pyrotechnic Signals)

Spring clip brackets for carrying the various signal projectiles are installed on the sides of the fuselage above the bottom gun aft of the co-pilot. See Figure 52. The signal cartridges are of the parachute type and may be furnished in red, green, or white lights for night use; or smoke cartridges for day use.

The pistol is stowed on a special bracket installed on the lower right longeron adjacent to the co-pilot's seat. The pistol is of the double action type with housed hammer and retracting firing pin, a trigger designed for two finger pull with a heavy flying glove, and a safety latch in the rear of the grip. A barrel release latch on the side is easily accessible to the thumb of the right hand.

The ready barrel release latch provides a means of instantly getting rid of a misfired barrel without opening the pistol or bringing it into the airplane, as the hazard of a misfire lies in the fact that it might be a hangfire in which the delay could be sufficient for the operator to open the pistol just before the cartridge fires. This hazard is eliminated in this type of pistol.

When the trigger of the pistol is pulled, the propelling charge projects the case containing the parachute signal or illumination flare away from the airplane and at the same time ignites the delay fuse. The delay on the fuse of the projectile is accurately timed for two seconds, which assures that the flare or signal will be well out of any possible interference with the airplane before the fuse flashes through and expels the parachute and burning candle. The propelling charges used for the different projector barrels are sufficient to carry the illumination flare a distance of about 45 feet and the parachute signal light or meteor signal light to a distance of about 150 feet.

E. Firing

In discharging the pistol it is advisable to fire with the elbow cocked, so the force of the recoil is absorbed by a rearward movement of the arm. It is recommended that firing be done slightly toward the rear and upward to insure against accidental contact of the projectile with the airplane and to obtain the maximum vision of illumination, depending on the altitude.

Additional information may be had by consulting the International Flare Signal Co., Tippecanoe City, Ohio, U.S.A.

SECTION XVIII

SURFACE CONTROLS

A. Description

The surface controls comprise the flight controls for the movable surfaces, that is, the elevators, rudder, and ailerons; and the controls for the auxiliary surfaces; the elevator trim tabs, rudder trim tab, and the aileron trim tabs.

The main control system for both the pilot and copilot consists of a wheel and control column operating the ailerons and elevators respectively and the foot pedals operating the rudder. In the rear cockpit, the aileron and elevator controls may be disconnected and the column stowed forward to permit use of the upper rear gun. Referring to Figure 65, this is accomplished by first disconnecting the wheel by turning the cam lock handle "A" on the wheel, 90° either way, and second, unlock the control column from the elevator cable by turning the knob "B" on the right side of the column. These locks are shown in Figure 5A. Push the column forward hard and latch in the friction spring clip provided on the fuselage bulkhead. A safety device shown in Figure 5A is provided on the control column to automatically unlock the machine gun carriage if it has been left in the extreme forward position with the copilot's flight controls connected. This prevents the pilot's controls from being fouled by the rear gun carriage.

The cockpit controls are connected to cast aluminum alloy quadrants on the elevator and rudder torque shafts by means of 3/16 in. extra flexible steel cables. The ailerons are connected to the operating crank arm by 5/32 inch extra flexible steel cables. Standard roller bearing pulleys are employed and phenol fiber fairleads are used to prevent interference with metal parts and for small changes in direction of the cables. The change of direction on a fairlead block is not more than 2°. Most of the bearings in the control system consist of sealed type ball bearings and require no lubrication, but in a few places plain bearings have been used at which Zerk fittings have been provided. Lubrication requirements are noted on the control system diagram Figure 65.

Auxiliary or trim controls for the elevators, rudder, and ailerons are provided for the pilot, the copilot having trim control of the elevators only. Longitudinal balance is affected by the pilot with a handcrank on the left side of the cockpit. A system of bevel gears and torque shafts equipped with universal joints operate a screw mechanism in the tail of the fuselage. Cables connect the screw mechanism to the trim tabs. The copilot is provided with a hand grip on the torque shaft for operating the controls. Lateral balance is controlled with an adjustable handle mounted on the forward side of the pilot's control column and connected to trim tab masts by means of cables in Bowden casings. The rudder trim control handle is mounted on top of the pilot's coaming above the instrument panel. The cable connections are similar to the aileron controls. Figure 4A shows the location of the pilot's controls.

B. Rigging

Due to the high speed characteristics of this airplane, it is essential that the control system cables be rigged reasonably taut in order to prevent vibration or flutter of the surfaces. The initial tensions to be rigged into the control cables are shown in the following chart. These values should be checked with the Glenn L. Martin Company hand tensiometer No. TC-46112, or equivalent tensiometer.

Aileron Control Cable - Wings	125 lbs. (56.7 kg.)	
Aileron Control Cable - Fuselage	60 lbs. (27.2 kg.)	
Rudder Control Cable	70-75 lbs. (31.7-34 kg.)	Elevator
Elevator Control Cable - Lower	70-75 lbs. (31.7-34 kg.)	
Elevator Control Cable - Upper	70-75 lbs. (31.7-34 kg.)	Supported
Aileron trim tab control cable	40 lbs. (18.1 kg.)	
Rudder trim tab control cable	30 lbs. (13.6 kg.)	Approx.
Elevator trim tab control cable	50 lbs. (22.7 kg.)	

These values are given for control cables rigged under generally stable conditions at sea level with the ground temperature not exceeding 80°F. It should be remembered that higher temperatures cause considerable expansion throughout the airplane which results in normal tightening of the cables on the ground. This condition is normalized while the airplane is in flight since higher altitudes are generally colder. In all possible cases it is recommended that airplanes be rigged during the morning when conditions more nearly coincide with the above.

When rigging the airplane care must be taken to provide sufficient travel in the Automatic Pilot Servo System, to prevent the pistons from bottoming in either direction. If properly rigged there should be not less than 5/8 inch additional piston travel available in any system when the corresponding control surface is moved to the extremity of its travel. Since no major adjustment can be made in the Servo Unit, the travel of the Servo pistons must be adjusted by means of the cable turnbuckles. The Servo pistons should be rigged into the cable systems with approximately equal travel provided at each side.

C. <u>Rudder Adjustment</u>

The rudder control system can be adjusted as follows:

1. Locate both foot pedals in the middle notch of the rudder pedal adjustment bars.

2. Clamp the pedal stirrups together and in line with a board, bar, or similar support.

3. Adjust the rudder buss cable until the stirrups are 2° forward of the vertical, measured from the horizontal centerline of the airplane. (A level protractor can be used to determine this condition whether the airplane is leveled or not).

4. Set the top Servo piston in the neutral position, that is, with equal travel provided at each side.

5. Take up all slack in the system using the two turnbuckles and vernier adjustment links in the bomb bay and the two turnbuckles in the tail of the fuselage.

6. Locate the rudder in the neutral position by measuring the distance from the bottom tip of the rudder trailing edge to the center of the bolt through the middle outrigger hinge of the elevator on each side of the airplane. This distance is approximately 75 inches, but the distances should be equal. Check the turnbuckles to ascertain that the proper threads are screwed into the barrels.

7. Remove the aligning support from the rudder pedals.

8. Check the travel of the rudder toward the right side by measuring the distance for the outrigger bolt to the rudder tip at the trailing edge. The 25° required will measure 60-5/8 inches.

   With the rudder in this position, tighten the rear stop cable attached to the right rudder quadrant until the rudder travel is fixed at this point. Check the clearance between the arm to which the left end of the buss cable is attached, and the bracket which supports the propeller governor control wheels. This clearance should not be less than 3/8 inches. If additional adjustment of the stop cable is required to provide this clearance, the turnbuckles or the vernier links in the bomb bay must be adjusted accordingly to maintain rudder travel. This in turn affects the buss cable adjustment.

9. Adjust the stop cable attached to the left rudder quadrant after determining the proper travel by measuring.

10. Recheck the complete system to determine the Servo piston travel through full rudder travel, and see that both sets of rudder pedals are equal.

11. Take up the front stop cables to the pilot's pedal quadrants.

12. Safety all nuts and turnbuckles.

D. Elevator Adjustment

To adjust the elevator controls:

1. Replace the front stop cable at the lower end of the elevator quadrant in the front cockpit with a rigid adjustable link, and adjust the control column 3° forward of perpendicular.

2. Place the middle piston of the Servo Unit in neutral, and remove the slack in the system. Adjust the cables until the center of the tie rod bolt in the bottom bell of the rear quadrant measures $10\frac{1}{4}$ inches to the center of Station 5D. The turnbuckle and vernier link assemblies located immediately aft of the front quadrant and just forward of the Servo Unit are used for this adjustment.

3. Adjust the turnbuckles in the tail of the fuselage until the elevator is raised 5° above neutral. Maintain the proper tension. Check with incidence board.

4. Replace the rigid link at the front quadrant with the standard stop cable. Adjust the stop cable until 15° downward travel of the elevator is provided. Measure with incidence board.

5. Check position of control column with elevators in neutral. The column should be between $4\frac{1}{2}°$ to $5\frac{1}{2}°$ forward of vertical.*

*NOTE: When adjusting the degree travel of the control column in the forward and rear positions with a protractor or template, the elevators should not be supported, but all loads should be taken by the cables. This is necessary because the weight of the surfaces and controls tend to stretch the long cables, and erroneous readings in the protractor setting may result if the weight is supported.

6. Check the clearance between the front elevator quadrant and the support bracket of the rudder quadrant. Clearance should be approximately 3/8 inch. Readjust as described above if necessary. If too much forward travel is had in the front column, increase the downward travel of the elevator surfaces 2^{o} for each single degree over-travel of the control column. Use the turnbuckles in the rear end of the fuselage. Readjust the stop cable at the front quadrant to bring the elevators back to 15^{o} for down travel.

7. If not enough control column travel is had after adjustments in paragraphs 1 through 5, reverse the process described in Par. 6.

8. Adjust the "UP" travel of the elevator to $31\frac{1}{2}^{o}$ by means of the top stop cable at the front quadrant.*

9. Engage the rear control column with the cable system and adjust the position of the column in the elevator down position. This adjustment is made in the push rod between the control column and the quadrant. There should be 1/8 inch clearance between the latch segments at the top of the column when properly adjusted.

10. Adjust the "UP" travel by lifting the elevators with the forward controls, and taking up the stop cable between the rear column and station 5A until it is just snug.

11. Recheck all turnbuckles for proper thread in the barrels, and safety wire. Safety the link nuts and lock the adjusting terminal nuts.

E. Aileron Adjustment

To adjust the ailerons:

1. Clamp the aileron cable quadrant, located on the aft side of the rear wing spar in the fuselage, in the neutral position.

2. Set the front control wheel in neutral and take up the cable turnbuckles in the bomb bay until proper tension is obtained.

3. Set the rear control wheel at neutral and adjust the rear cable system until the bottom Servo piston is as near center as possible, with the required tension provided.

   The one turnbuckle and vernier link provided in this system are located below the Servo. Two holes are provided in the terminal end of the Servo piston rod for slight adjustment. Due to this small possible adjustment, it is important that this cable be made as near the required length as is necessary to hold the Servo piston neutral.

4. Adjust the cable system in both wings until the ailerons are neutral with the wings, and proper tension is obtained. The turnbuckles are located at the wing gap and are reached from the bottom.

5. Before safetying the links and turnbuckles make sure the turnbuckles are adjusted with the proper threads in the barrels.

6. Release the clamp arrangement at the quadrant in the fuselage.

*See note, bottom of page 1802.

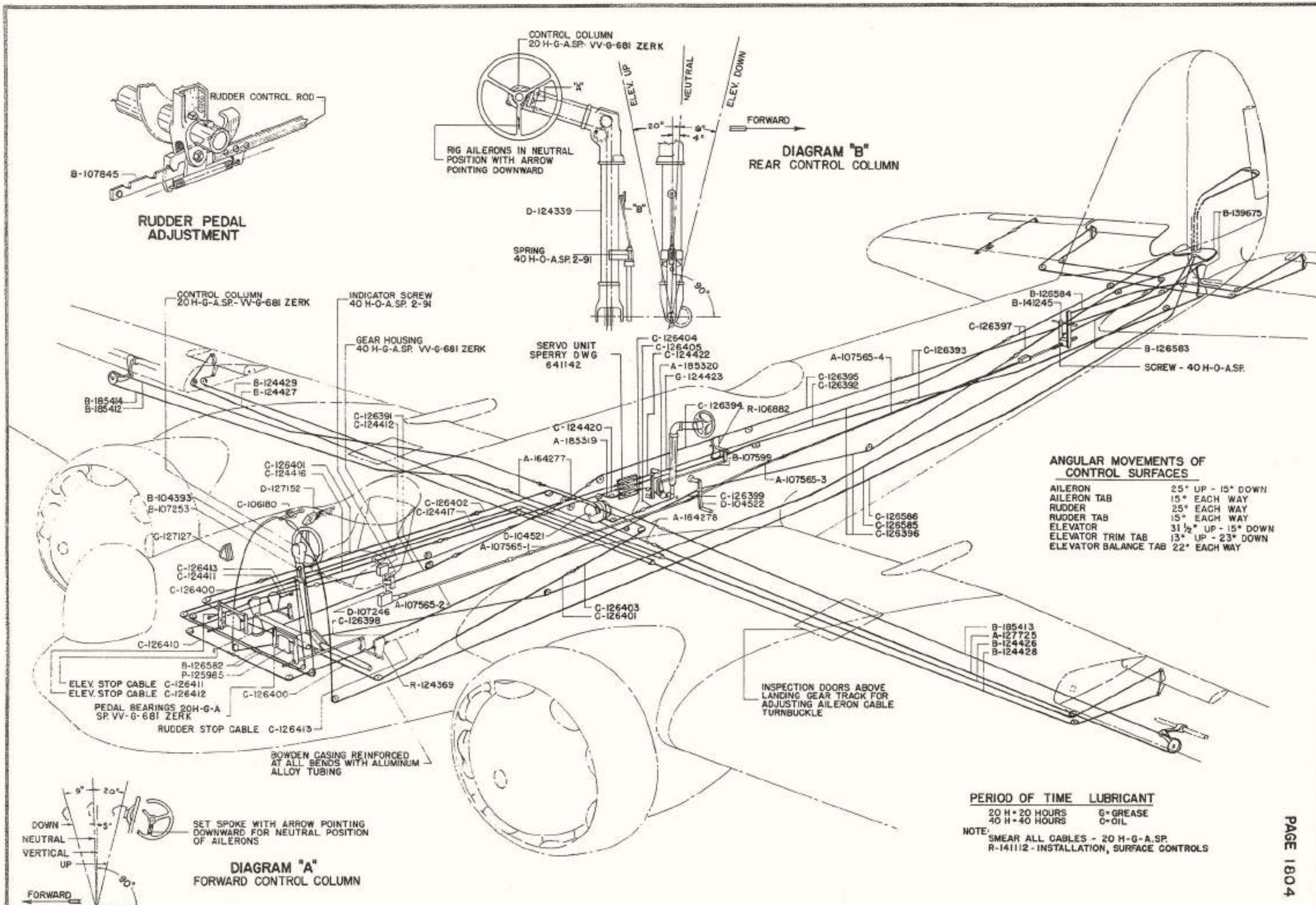


FIGURE 65 MODEL 139-W SURFACE CONTROL DIAGRAM

C

F. Aileron and Rudder Tab Adjustment

With the control handles in the neutral position, the cable turnbuckles should be adjusted until the tabs are centralized with respect to the parent surface. The movement of the aileron tab is limited to 15° each way by stops provided on the chain segment in the column.

The movement of the rudder trim handle limits the travel of the rudder trim tab. No limit adjustment is provided other than the handle. For this tab, 15° movement each way is provided.

G. Elevator Trim Tab Adjustment

To obtain the desired tab travel, the controls must be rigged with the indicator out of position in the pilot's cockpit. The required travel of the tab is 13° UP and 23° DOWN. This travel is adjusted by placing the indicator in the cockpit in the neutral position, and taking up the turnbuckles in the rear of the fuselage until the tabs are 5° DOWN. Tension is placed in the system by means of the buss cable between the two trim tabs.

H. Maintenance

At the twenty hour inspection periods:

1. Inspect all cables and pulleys (including all quadrants) to make sure that the cable is in the groove and is not chafing. Replace all frayed or worn parts. Replace any control cable when a frayed place is discovered. With normal operations, it is believed that most control cables will need replacement about every 300 hours, although this figure may vary widely depending upon circumstances.

   Caution should be exercised in searching for broken strands which often are found in the core of the cable and are not visible until the cable is carefully kinked into a U-shaped loop at the suspected places. Merely running the fingers along a cable having an internal break will not locate the trouble; but frayed ends among the outer strands can usually be detected by drawing the fingers along the cable. In certain climates, hidden corrosion of the inner strands may also be discovered in the above manner and should be watched for.

2. Inspect control surface hinges (including the aileron horns) for perfect operation.

3. Check rigging of the system and take up any slack that may be in the system due to a slight stretching of cables.

All cables should be cleaned every 40 hours where they pass over pulleys or through fairleads, and covered with heavy rust-preventative compound. (See Appendix IV).

I. Lubrication

All lubrication points, periods of lubrication, and the proper lubricants to use are noted in Fig. 65 (also see table of greases in Appendix IV).

J. Sperry Automatic Pilot (Applies Only to Airplanes so Equipped)

1. Description

The pilot's Directional Gyro and Bank and Climb Gyro Units are mounted on a separate removable panel in the center of the main instrument board. These units are installed by sliding them onto the tracks of the mounting unit which is usually left in place behind the instrument board.

The mounting unit is supported in the airplane on four 6-pound capacity "Lord" rubber shock absorbers and is accessible through the hatch provided in the top of the fuselage forward of the pilot's cockpit.

Note: When installing the flight gyros in the mount, it will be necessary to exert considerable pressure against the gyro units to provide a good air seal around the connections. This is accomplished by means of the "hold on" screws on the front side of the gyro panels which should be tightened alternately a little at a time until the gyro units are firmly seated.

Air relays, balanced oil valves, and follow-up pulleys are attached to the back of the mounting unit and are accessible through the hatch.

The complete system is shown diagrammatically on the Sperry equipment outline drawing No. 75688-F which is furnished in the Accessory Bulletin cover. The oil pressure is supplied by a Pesco oil pump installed on the left engine (Figure 65A). The pump is connected to an oil sump located on the front side of the firewall in the left engine nacelle, and also to an oil pressure regulator located adjacent to the sump tank. The pressure regulator is also connected to the sump so that oil can be bypassed around these units when the servo unit is shut off. The oil is piped to the speed control valves located on the auxiliary control panel at the pilot's right. An oil filter is located in this line adjacent to the sump, and a Servo oil shut-off valve is provided in the line and located above the longeron on the right side of the cockpit. A line from the shut-off cock to the speed control valves is also connected to the pressure gauge, both of which are located on the auxiliary control panel at the pilot's right. See Figure 4A. Shutting off the oil supply stops the operation of the Servo Unit and speed controls but does not affect the operation of the Gyro instruments.

Vacuum for all the Gyro instruments is supplied by two interconnected Pesco vacuum pumps, one installed on each engine. An Eclipse check valve in each line assures operation of these instruments in case one engine is shut down.

2. General Inspection and Maintenance

(a) Adjustment of Gyros

The trim position of the Automatic Pilot in the airplane should be checked at the engine overhaul period or between 300 and 400 hours. This is accomplished by placing the airplane in the normal flight attitude and then adjusting the retaining bolts in the shock absorbers on the mounting unit. These bolts are accessible through the hatch forward of the cockpit.

(b) Inspection

The Automatic Pilot system should be completely gone over during the 40 hour inspection and should be checked for the following:-

Inspect all piping, fittings, and pumps for leaks. Tighten any loose fittings or clamps. Replace any doubtful parts and those showing signs of failure. See Section II-B for pipe line identifications.

Check the follow-up cables for wear, paying particular attention to stranding or fraying. Bend the cables at the sections which pass over the pulleys to see if any internal strands are broken. Check follow-up cables for sufficient tension.

Inspect the air screens in the Gyro instruments and clean. One screen is provided in the Directional Gyro control unit, two in the Bank and Climb Gyro control unit, and one in the Vacuum Relief Valve.

Check oil in the sump tank for 3/4 full. Maintain this level with Servo Oil. No other kind of oil shall be used. (See Table in Appendix IV for Oil specifications).

At engine overhaul periods (approximately 300 to 400 hours) the control units should be removed and given a bench check.

Replace worn rubber grommets back of the control units.

Drain the oil tank and sump and remove the strainer for cleaning in gasoline. Do not use high test (lead base) gasoline for cleaning.

Remove the oil and vacuum pumps for cleaning in gasoline. Inspect the driving end of each for wear and check the freedom of rotation. Do not disassemble the pumps unless absolutely necessary.

Replace any weakened flexible hose connection.

After reinstallation of the system units, supply the oil tank with one gallon of the oil. Check the supply (especially after ground testing procedure) to ascertain the proper level of oil. A sight gauge is provided on the tank for checking the oil level.

The installation of the vacuum instruments is shown on the "Installation Aeronautical Instruments" drawing listed in Appendix III. The Pesco oil and vacuum pumps are covered in detail in Pesco Accessory Bulletins listed in Appendix II. Drawings showing the assembly of the Oil Pressure Regulator and the Oil Filter are furnished with the accessory bulletins.

Ground checking the Automatic Pilot is covered in detail on page 47 in the Sperry Instruction Manual No. 15-726C which is furnished with the miscellaneous accessory bulletins. The instructions given therein are applicable to the 139-WH3 airplane except that the operating oil pressure has been adjusted to 75 lbs./sq.in. (5.27 kg./sq.cm.).

Flight tests made with the Pilot system set at this pressure have proven satisfactory at the factory. Should it be necessary to readjust the oil pressure to any value other than the above to obtain stable flight, the pressure should be at least 10 lbs. higher than the lowest pressure at which the Pilot will function properly in normal weather when flight tests are made. The additional 10 lbs. pressure should be sufficient to overcome any possible gust loads encountered in bad weather.

It should be remembered that the oil pressure must be adjusted with the speed valves closed. If the pressure is adjusted with the speed valves open, the result will be an increase in oil pressure when the valves are closed for adjustment of the Pilot in flight. Excessive pressure will cause jerky control and places too great a load in the balanced oil valves of the Servo.

On the other hand, if oil pressure is too low, it will be necessary to open the speed control valves so far to operate that the return action of the Pilot from an out of trim condition will be extremely slow and thus cause the airplane to hunt.

3. Vacuum System

There are three vacuum relief valves in the system located as follows: one adjacent to each engine driven vacuum pump shown in Figure 65A, and one in the main line at the right side of the pilot's cockpit shown in Figure 71. The pump relief valves are adjusted by means of a knurled nut on top of the valve. Turning these nuts OUT will increase the vacuum. The rear relief valve is adjusted by means of a screw located under the acorn shaped cap on top of the valve. Turning this screw IN increases the vacuum. This valve may be reached from the bomber's compartment by loosening the draft curtain.

To adjust vacuum:

(a) Adjust the rear relief valve (in pilot's cockpit) to maximum output by turning adjusting screw all the way in.

(b) Adjust each pump relief valve separately to 4.75 in. Hg. with engines running at 1500 RPM.

(c) Readjust rear relief valve to 4.25 with engines running at 1500 RPM.

(d) When starting engines, be sure Gyro units are NOT caged.

(e) Recheck operation of controls by turning the knobs on the Gyro unit.

(f) Follow the instructions on the plate attached to the Gyro unit.

4. Operation of Automatic Pilot

Complete instructions for the operation of the Automatic Pilot are given in the Pilot's Section, II-A of the Maintenance Manual.

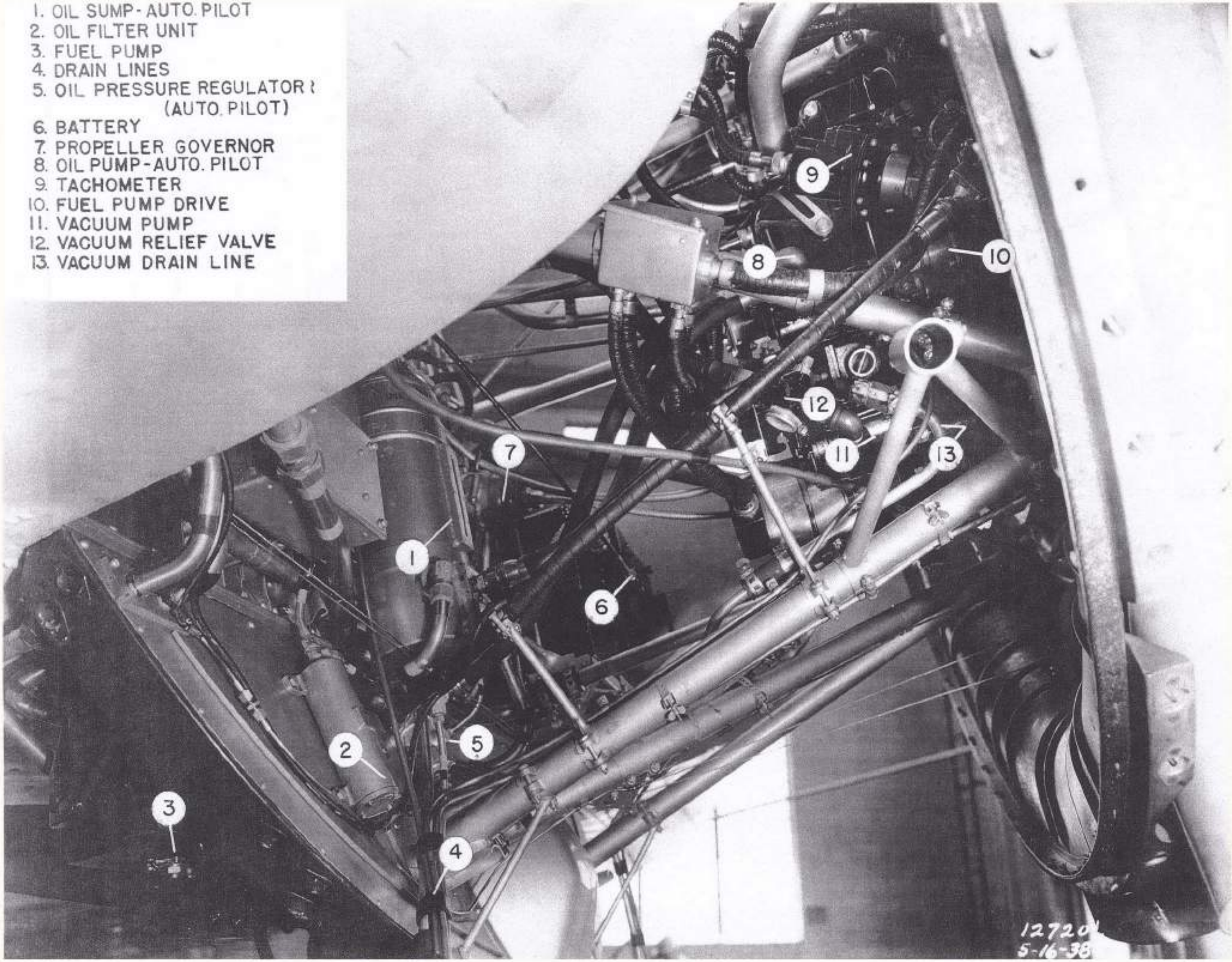


FIGURE 65A. AUTOMATIC PILOT EQUIPMENT IN NACELLE - LEFT ENGINE

SECTION XIX

ELECTRICAL SYSTEM

A. Special Data (See drawing numbers in Appendix III)

Figure 66 shows the general arrangement of the Electrical Installation. This installation comprises two main systems:

1. A mechanical system consisting of terminal boxes, conduit, clamps, etc., and shown on the "Installation Fuselage Electrical Equipment" drawing and the "Installation Nacelle Electrical Equipment" drawing.

2. A system of supply and return wires is shown on the Electrical Wiring Diagram A simplified diagram is shown in Figure 67.

B. Description

In general, drawn seamless aluminum conduit is used throughout the airplane. Flexible conduit is used in the engine nacelles and at certain points in the fuselage where flexibility is necessary. The cables at the terminals of the navigation lights, landing lights, gunner's instrument board, and magneto ground at engine are braid-shielded. Conduit sections are joined together with standard conduit unions. Care should be exercised in case conduit is removed and replaced that the ends be smooth and even, and that all conduit clamps are tight. Rough conduit ends invariably injure conductor insulation and may cause short circuits. Sharp dents should also be avoided because of the pinching effect of the wires. Shielded connector panels (junction boxes) are provided at junction points in electrical circuits.

The electrical section of the pilot's instrument board is completely shielded. Access to the inboard panels is obtained by removing the screws around the outer edge of the panel and hinging the panel aft, the wires being long enough to permit this. The nuts for these screws are anchor elastic-stop-nuts. The main electrical panel is attached with Dzus fasteners which permits access to instrument side of panel. An access door is also provided on the front side of this compartment.

The landing and navigation light conductors are continuous from the landing light boxes to the engine nacelle box. Before removing an outer wing, the wires should be disconnected at the nacelle box, the splice union at the wing gap disconnected, and the wires pulled through from the engine nacelle into the gap between the wings. It is not necessary to remove the lugs on the ends of the wires in order to pull them through this conduit which is short.

No wires should be withdrawn from an extremely long conduit without first removing the lugs and attaching a fish wire to the conductor. Some trouble may be experienced in assembling new wires unless the above precaution is taken. Non-metallic identification tags numbered to agree with the Wiring Diagram are used throughout; and a wire marker legend is attached inside each box cover. Therefore, when connecting up any wires in terminal boxes such as at the engine nacelle, the wire should be placed on the post which corresponds with the same number as the wire.

Care must be used in handling small diameter conductors in terminal boxes in view of the possibility of either breaking the cable where it is soldered to the lug, or the lug itself. Repeated breaks in the wire necessitate the replacement of the conductor.

A spare bulb box for the instrument panel light bulbs is provided on the right side of the fuselage near the pilot's instrument panel and in the rear cockpit on the cable guard aft of the rear spar. The bulbs in the rear cockpit may be replaced by unscrewing the retainer cap on the rear face of the boards, pulling out the old bulb, and inserting the new one. For access to bulbs in pilot's panel, remove instrument panels.

C. Landing Gear Electrical System

The maintenance and operation of the landing gear electrical system is discussed in Section IX.

D. Ignition

The magneto low tension leads are continuous except for junctions in distribution panel and in each nacelle which will permit removal of the engine without disturbing the entire length of wire. They are assembled separately shielded from other conductors. A metal shielding box is provided over the ignition switch inside the electrical compartment of the pilot's instrument panel.

E. Generators and Voltage Regulators

An Eclipse Type E-5 Generator is mounted on each engine. A Type A-1 Leece-Neville Voltage Regulator for each engine is installed in a shielded box located on the left side of the fuselage in the bomber's compartment.

The generator output is 50 amperes each at 15 volts (rated voltage) at 2250 to 3750 r.p.m. A minimum speed of 2250 r.p.m. is obtained at an engine speed of 1500 r.p.m. The control box limits the operating voltage to 14.6 volts (max.) and the current to 55 amperes (maximum).

The purpose of voltage regulation is to control the voltage of the system under conditions of variable load, changing speed, and differences in operating temperatures. The voltage regulator element is designed and made to accomplish this purpose and will do so when correctly adjusted.

A voltage regulated generator charges the battery connected to it at a current rate which corresponds to the state of charge of the battery. When the battery is in a discharged condition, the charging rate will be high, and when the battery is fully charged or nearly so, the charging rate in amperes will be low. This results because the voltage of a regulated system approximates a constant potential. The voltage effective in charging a battery is the difference between the applied charging voltage and the counter or back voltage of the battery. When the battery is in a discharged condition, this difference is comparatively great. As the battery charges, the voltage of the battery increases, approaching the applied charging voltage and the difference between the two diminishes, resulting in a tapering rate in amperes as the charge proceeds. Continuous charging of a discharged battery on a voltage regulated system will result in the charging current decreasing to a low value as the battery becomes fully charged.

Voltage regulated systems operate automatically to protect batteries from overcharging, and to charge at a high rate only when needed, insuring longer battery life and efficient operation. Another function of controlling the voltage is to provide a suitable source of electrical energy for the operation of radio apparatus.

The generator current output also depends upon the external load in use. The voltmeter mounted on the electrical panel on the left side of the pilot's cockpit is connected to a double contact switch so that the controlled voltage being supplied by either generator can be read. The voltmeter should show 14.6 volts with either generator operating. Two ammeters are provided in the electrical panel, one for each generator.

When the engine speed decreases sufficiently to allow the generator voltage to drop below 13.5 volts, the generator control box automatically disconnects the battery from the generator circuit, thus preventing tne discharging of the battery through the generator when the latter is at rest or operating at a speed below that required for battery charging. The control box also limits the current output of the generators to 55 amperes to prevent overheating under too large a load.

Complete instructions covering the Generator Voltage Regulator Control Unit are printed by the Leece-Neville Company of Cleveland, Ohio. A copy is furnished with the accessory bulletins accompanying each airplane.

CAUTION: The generators do not deliver a fixed amount of current. The output depends upon the condition of the battery and the external load in use. It is extremely important that no attempt be made to adjust the control box units so that the generator will deliver a certain amount of current as damage will result. Let the current be what it may, and adjust for voltage only by turning the adjusting ratchet wheel to the right to increase the voltage and to the left to decrease the voltage. The voltmeter should record a voltage of 14.4 to 14.6 volts with the engines running at about 1500 r.p.m. and the battery disconnected. (A piece of clean paper placed between the contacts of the reverse current relay may be employed instead of disconnecting the battery).

F. Curtiss Propeller Installation

A detailed description of the propeller and its component parts is contained in the Installation and Maintenance Instructions for Curtiss Constant Speed Propellers, which accompanies each airplane.

A description of the installation in the airplane is given in paragraph **K**, Section X (Maint. Manual). The electric wiring installation is shown on the Simplified Electric Wiring Diagram, Figure 67.

The operating instructions are given in paragraph P, Section II-A, (Maint. Manual) and in the Pilot's Manual.

G. Bonding

All airplane parts which do not make good electrical contact with the airplane structure are bonded to the nearest main metal part of the airplane structure. Bondings provide a good electrical connection between parts, the resistance of which is approximately the same as that which would exist if both connectors were an integral part. The resistance of bonds used throughout the airplane does not exceed .004 ohms.

It is necessary in making bonds that the metal parts be free of protective coat ing or finish except that of metal plating, before the parts are joined. After the bond is made, a protective coating should be applied to the structural members.

Bonds may be made either by soldering, bolting, or clamping, soldering being preferred. Resin flux should be used for soldering in all cases except where steel members are involved. When renewing bonds, braid woven from 120 strands of No. 36 tinned copper wire should be used. The ends of the braid in which a hole is to be made for making connections should be dipped in solder to prevent fraying of the strands.

It is extremely important that all bonds be securely replaced against clean surfaces after the installation of any bonded parts that were removed.

H. Batteries

The two batteries provided are located in the engine nacelles and are rigidly supported by brackets bolted to the front wing beam. Each battery is contained in an acid proof case which is drained through a rubber tube contained in a metal conduit, so installed as to permit the escape of acid and gas. Whenever the battery is removed, the drain tube should be inspected and blown clean.

Keep the battery container and surrounding structure painted with acid proof paint as required. Cleaning the battery and case with a solution of ammonia or of baking soda (in the proportions of one pound of soda to 1 gallon of water), then rinse with water and dry. Do not allow the solution to enter the battery cells.

The battery terminals may be kept clean and free from corrosive action by applying a thin coat of vaseline or No-OX-Id grease. Inspection should be made at approximately two week intervals and if necessary, add distilled water to the cells.

Additional instructions covering the Installation and Operation of Exide Batteries are furnished with the accessory bulletins.

I. Carburetor Mixture Thermometer

The Weston Resistance Type Thermometers used to indicate the mixture air temperature in each carburetor consists essentially of an indicator, resistance bulb, and interconnecting wiring. The two indicators are installed on the right side of the torque tube above the rudder (Figure 4A). The indicators are suitably calibrated and adjusted for use with the copper-constantan thermocouples installed in the carburetor. The adjustment allows for an external circuit resistance of 2.00 ohms which includes the thermocouple and leads. The indicator is self-compensated for changes in cold-end temperature and corrections do not have to be applied for variations of panel temperature. The indicator scales are calibrated in degrees centigrade.

WARNING: To prevent damaging the indicator, it is very important that the positive lead to the resistance bulb be connected; or that the indicator circuit is disconnected in the junction box located in the upper left side of the fuselage, forward of the pilot's instrument panel. This applies to any condition where it is necessary to close the battery cutout switch.

When installing the resistance bulb, clean the threads on the mounting outlet and add a drop of oil. Thread the resistor bulb into the outlet and make certain the plug connector end is protected from oil or water seapage. If an accumulation of seapage is allowed between the plug connections, it will shunt out part of the bulb resistance and result in an error in indication.

J. Oxygen System

The electrical conduit containing wires for connecting the oxygen equipment are installed in the fuselage. The wire connectors are shown on the Simplified Electrical Wiring Diagram, Figure 67A. The position of the equipment is shown in Figure 66.

Instructions for the systems consist of installing the equipment on the brackets provided and making the proper connections, referring to the drawings.

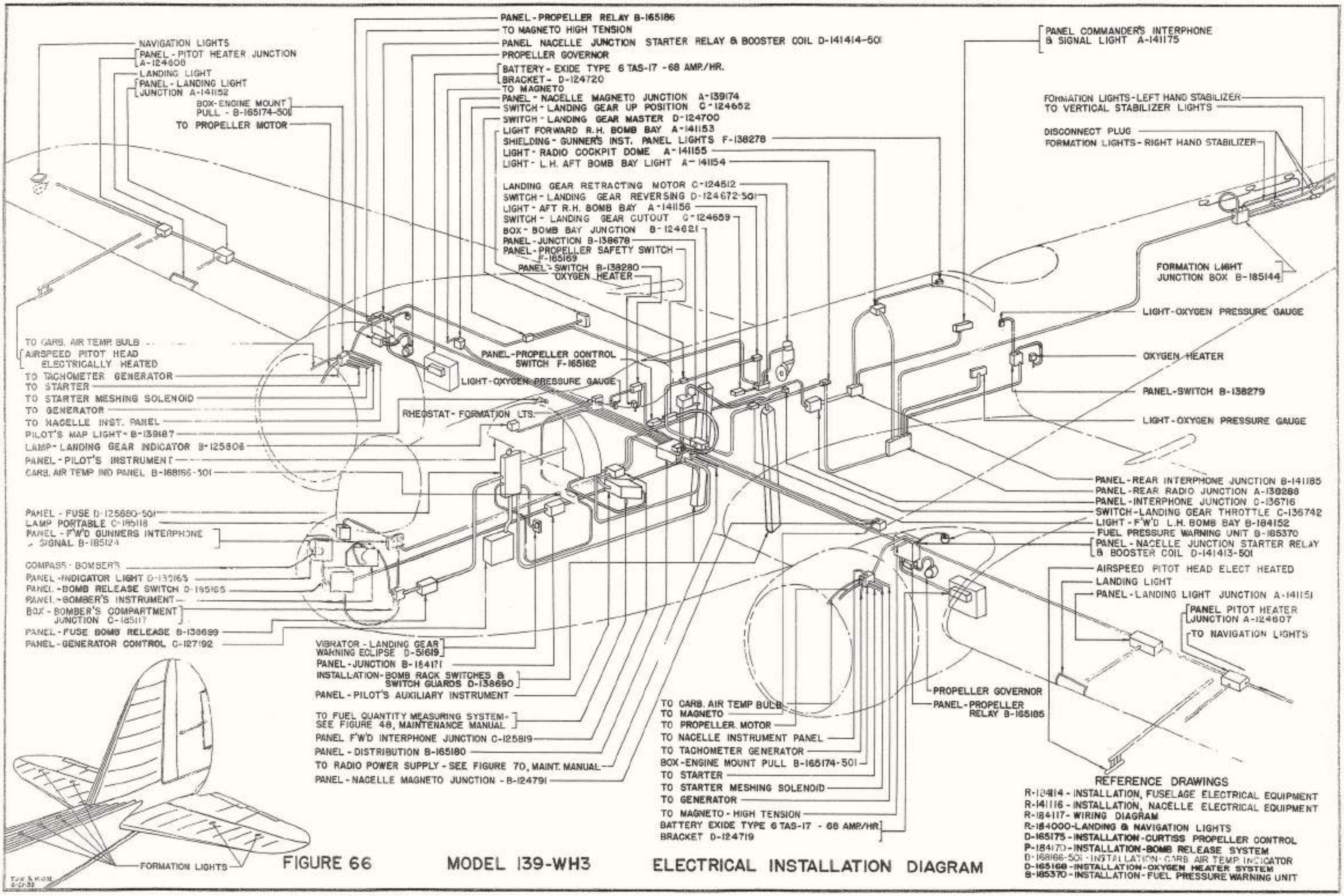


FIGURE 66 MODEL 139-WH3 ELECTRICAL INSTALLATION DIAGRAM

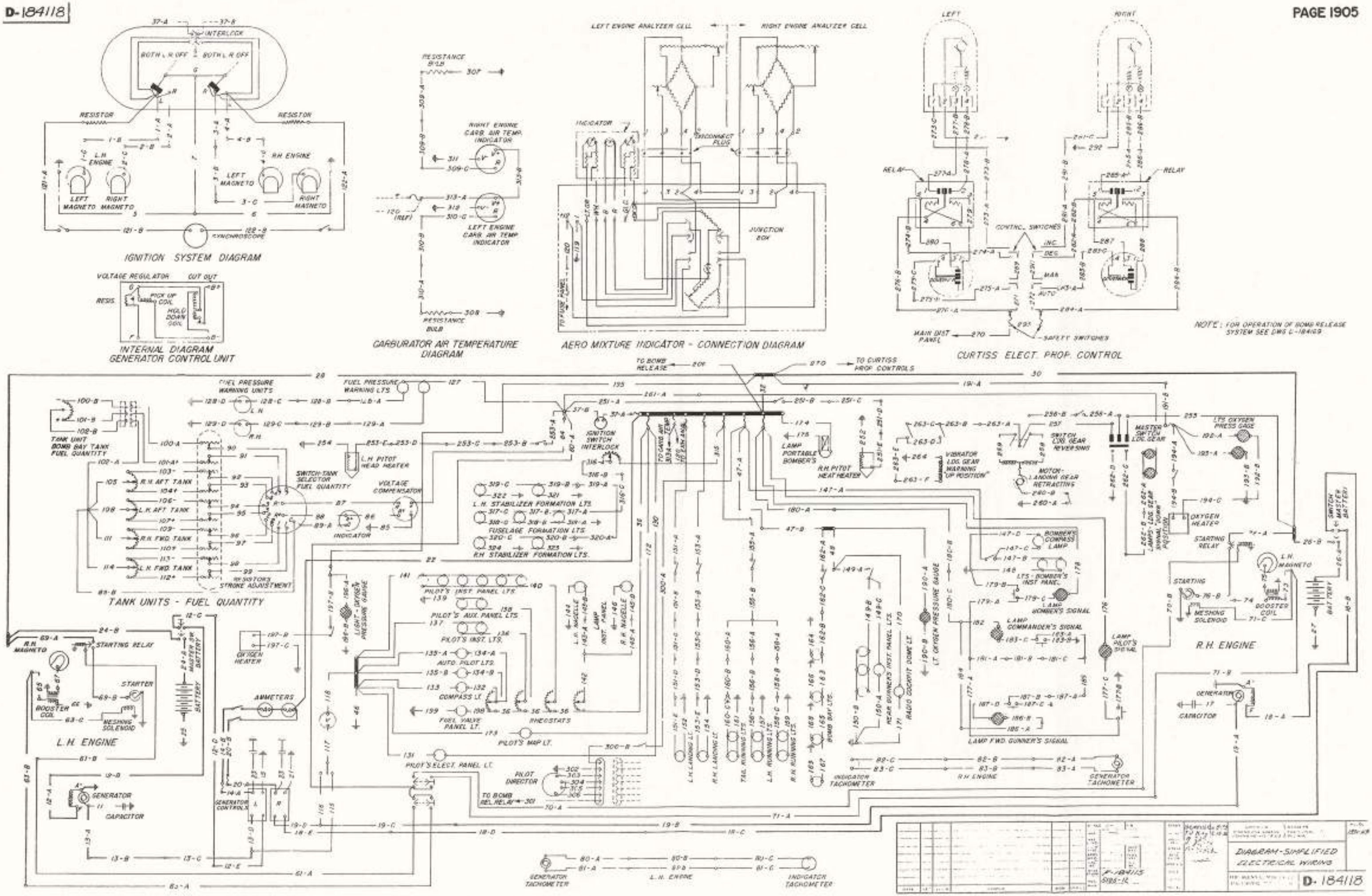


FIGURE 67 MODEL 139-WH3 SIMPLIFIED ELECTRICAL WIRING DIAGRAM

SEE FIGURE 67-A FOR OPERATION OF BOMB RELEASE SYSTEM

SECTION XIX-A

ELECTRICAL BOMB RELEASES

A. General

The internal and the external bomb release systems installed in these airplanes are each independently operated. Separate electrical and mechanical controls are provided for each system; the release switches however are installed on the same box. See Figure 60. The bomber's mechanical controls are shown in Figure 60A. The pilot's emergency controls are shown in Figure 5.

The electrical release system for the internal racks consists of the following equipment:

1. FUSE PANEL for supplying power to the electrical equipment.

2. INDICATOR LIGHT PANEL giving the bomber a visual indication of the bomb stations that are cocked and released.

3. Bomber's SWITCH PANEL for releasing bombs.

4. A BOMB SIGHT and mechanism for directing the pilot's course.

5. A PILOT DIRECTOR mounted on the pilot's instrument panel.

6. A RELAY for operating the bomb release circuits.

7. Nine SPECIAL SWITCHES and SOLENOIDS for operating a 9-station bomb rack.

The installation of this equipment is shown in Figures 58 through 60. Complete information on wire connections is shown on the Installation-Bomb Release-Electrical drawing (see Appendix III). A simplified wiring diagram for this system is shown in Figure 67A.

A complete system of conduits and junction boxes is provided to shield all interconnecting wires, fuses, terminals, etc., except short leads to solenoids and leads to the Pilot Director handle. All conduits are bonded to the structure of the airplane in accordance with U. S. Army Air Corps Specifications.

The external bomb rack controls are described in paragraphs F and G.

B. Description - Internal Racks

1. Fuse Panel

The fuse panel is located in the bomber's compartment on the left-hand side of the airplane aft of the machine gun turret. This panel contains a 100-ampere fuse in the positive supply lead to the electrical bomb release equipment and a 5-ampere fuse for the indicator lights on the bomber's indicator panel. A spare 5-ampere fuse is located on the forward end of the box inside of the panel. A spare 100-ampere fuse is located outside on top of the panel.

2. Bomber's Switch Panel

This panel is located in the bomber's compartment on the right-hand side of the airplane. It is located conveniently for operation of the various switches which control the releasing of bombs. This panel contains the following equipment:

a. A master switch controlling all the electrical bomb release equipment.

b. A push button for releasing bombs.

c. A throw-over switch for controlling bomb releasing (train or selective).

d. Terminal blocks for electrical wiring interconnections.

3. Indicator Light Panel

This panel is located in the nose of the airplane in full view of the bomber when the latter is at his station during bombing operations. This panel contains the following equipment:

a. Five green lights corresponding to the 5 bomb stations on the left-hand side of the airplane.

b. Four red lights corresponding to the 4 bomb stations on the right-hand side of the airplane.

c. A switch for supplying power to the indicator lights.

d. A test switch for testing the indicator lights without loading the bomb racks.

e. A perforated cover for masking the indicator lights at night.

f. A spare bulb and lamp extractor compartment.

g. Terminal blocks for electrical wiring interconnections.

4-5. Bomb Sight and Pilot Director (This equipment furnished and installed by the airplane purchaser.)

Electric wiring is installed in the airplane between the switch panel and the main instrument panel for the installation of the Pilot Director. Provision is made for mounting the Bomb Sight in the bomber's compartment (see paragraph D, Section XV). A switch is provided on the left-hand side of the bomber's compartment for switching the Pilot Director "On" and "Off".

6. Bomb Release Relay

This unit is located on the right-hand side of the airplane aft of the bomb release switch-box. This relay closes the main bomb-release circuits when it is energized by pressing the push-button located on the bomb release switch panel, or when the bomb sight automatic switch is in operation.

7. Bomb Rack Switches and Solenoids (See Figure 67-A)

The bomb racks furnished with this airplane have been modified for electrical "train" and selective releasing of bombs. The electrical equipment at a typical station consists of the following:

a. A solenoid for tripping the bomb release mechanism.

b. A switch, whose function is as follows:

(1) Energize the solenoid, thereby releasing a bomb.

(2) Break the circuit which energizes the indicator lamps as long as a bomb is in place.

(3) Extend the solenoid energizing circuit to the next bomb station.

(4) Bridge the solenoid energizing circuits at all unloaded bomb stations.

These switches are shielded in a housing attached to the forward side of the front rails of each rack. A hinged cover is provided on the housing and is secured by trunk-type latches (Figures 58 and 59). Access to the switches is obtained by swinging back the cover.

The solenoids are encased in a housing forming a part of the mechanical bomb release mechanism. These solenoids cannot operate unless the bomber's mechanical bomb release handle is in the "Selective" position.

C. Operation of Electrical Bomb Release System

1. Install one 100-amp. fuse and one 5-amp. fuse in the fuse panel for the bomb release system.

2. Turn the bomb indicator light switch to the "On" position.

3. Turn the indicator light test switch to the "Test" position. All lamps should light up. Replace defective lamps if necessary, using the lamp extractor provided in the spare bulb compartment.

4. Return indicator light test switch to "Off" position.

5. Load bomb racks. An indicator lamp will be lighted for each cocked bomb station. These indicator lamps can be switched off after loading the bombs into the airplane and switched on again during actual bombing operation. The bomb release mechanisms at unloaded stations should not be cocked since this will give a wrong indication of loaded stations on the bomb indicator light panel. The electrical bomb releasing system will operate with any combination of loaded stations.

6. Set "Train"-"Selective" switch in either the "Train" or "Selective" position.

7. Turn the bomb release master control switch to the "On" position.

8. Set the control handle in the bomber's compartment to the "Selective" position. This handle locks the solenoids in the "Locked" position and releases all the bombs at once in the "Salvo" position. The "Selective" position is used for electrical operation of the bomb racks.

9. For manual operation of the bomb release system, press the push button on the bomb release switch panel. If the "Train"-"Selective" is in the "Selective" position, one bomb is released. The push button must be allowed to return before another station can be released. If the "Train"-"Selector" switch is in the "Train" position, all the bomb stations are released successively in "Train."

10. The indicator lamp for a particular cocked station will go out as soon as that station is released.

11. The detail operation of the switches on the bomb racks is shown on the Simplified Wiring Diagram, Figure 67-A. This diagram shows the switches, solenoids, and bomb release devices throughout the complete cycle in either the "Train" or "Selective" operation of the electrical bomb release mechanism.

D. Adjustments

A sample bomb rack switch, solenoid, and tripping mechanism was tested at the Glenn L. Martin Co. 2000 consecutive times without showing any signs of wear, arc pitting, or elongation of holes. The electrical release mechanism as installed at the factory should not ordinarily require any further adjustments. However, if adjustments are necessary, the following procedure is recommended:

Referring to Figure 67-A,

1. Set mechanism for releasing.

2. Note the amount by which the brass bushing projects beyond contacts "A" and "C".

3. Release mechanism electrically or by hand.

4. Note the amount by which the brass bushing projects beyond contacts "B" and "H".

5. The amounts in paragraphs 2 and 4 should be equal. If they are not, remove and add sufficient washers under the last insulating bushing to bring about equality.

6. Reset mechanism for releasing.

7. Note the amount by which the brass bushing projects beyond contacts "D" and "F".

8. Release mechanism electrically or by hand.

9. Note the amount by which the brass bushing projects beyond contacts "F" and "E".

10. The amounts noted in paragraphs 7 and 9 should be equal. If they are not, remove or add sufficient washers under the last insulating bushing to bring about equality.

11. The metallic and insulating bushings should be removed in order to inspect the phosphor-bronze spring contacts.

E. Legends

Legends are located in all junction boxes, panels, and switch guards to facilitate the removal and re-installation of wires and units without the necessity of consulting the wiring diagram.

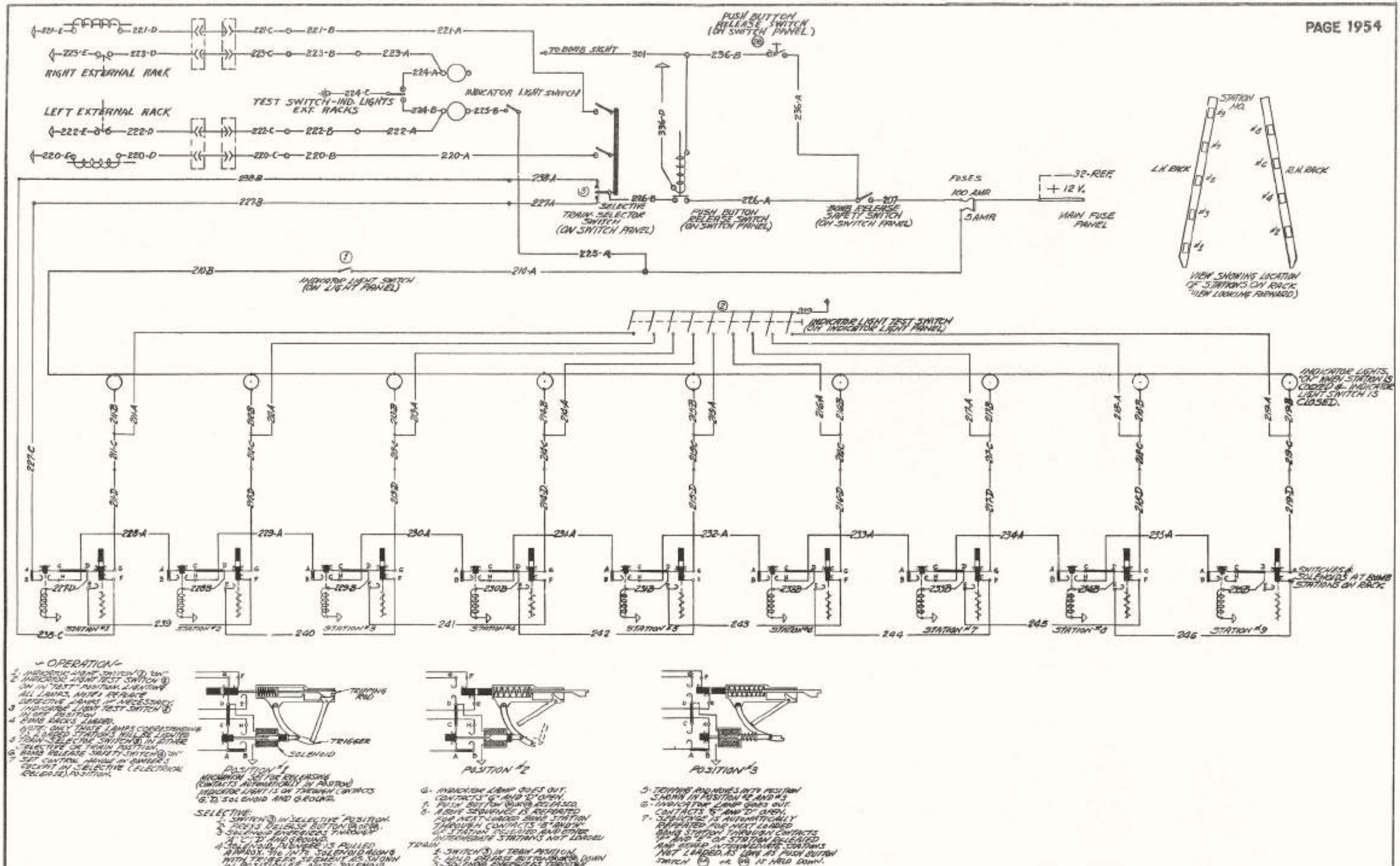


FIGURE 67-A MODEL 139-WH3

SIMPLIFIED WIRING DIAGRAM - INTERNAL BOMB RACK

F. Description - External Racks

The fuses contained in the panel on the left side of the fuselage are used in the external system. In addition to the internal rack switch controls, the bomber's switch panel contains:

1. Two, 2-position toggle switches for energizing the circuit to each external bomb rack.

2. An indicator lamp for each rack - covered by a slide to dim the light.

3. A two position switch for operating the indicator circuit.

4. A test switch for checking which rack is loaded by means of the indicator.

5. Switches and Solenoids

The left and right external release switches are wired in series with the master switch and the push-button switch for the bomb release relay. Operation of either rack solenoid is accomplished after the master switch is closed, and by pressing the push-button switch.

Note: To prevent inadvertent electric release of the rack solenoid, a spring loaded locking pin is provided in the rack mechanism adjacent to the solenoid. Control of this lock is provided the bomber with a handle located on the right side of the fuselage. This lock is in addition to the master switch which also prevents the racks from operating if it is in the off position. With the mechanical lock closed, the bomb switches for the external rack should not be held closed as there is danger of burning out the solenoid.

The external racks are equipped with a solenoid which trips both large and small hooks in the rack simultaneously if both sets are cocked. A cable attached to the solenoid cocking lever closes the indicator light switch at the solenoid when it is cocked. The circuit to the indicator lamp is not closed until the toggle switch on the bomber's panel is operated.

G. Operation of the External Release System

1. Install one 100-amp. fuse and one 5-amp. fuse in the fuse panel for the bomb release system.

2. Turn the bomb indicator light switch to the "ON" position.

3. Turn the indicator light switch to the "Test" position. The corresponding lamp for the solenoid cocked should light. Replace defective lamps if necessary, using the lamp extractor provided in the spare bulb compartment in the internal rack indicator.

4. Return indicator light test switch to the "OFF" position.

5. Be sure the rack locking handle in the bomber's compartment is in the off or "SAFE" position.

6. Load the bomb racks as described in Section XV, paragraph K.

7. Just prior to actual bomb release, move the locking handle to the "ARM" position. THIS IS IMPORTANT.

8. Set the external rack switch for the bomb to be released to "ON."

9. Place the bomb release master switch in the "ON" position.

10. Release the bomb by pressing on the button switch.

11. Both external racks can be released simultaneously together with the internal racks to salvo all bombs that may be carried on the racks. To electrically salvo all racks the two external rack switches must be "ON" and the internal rack switch must be placed at "TRAIN." Pressing the release switch closes the circuit to all the rack solenoids.

SECTION XX

RADIO

A. General

Provision is made in this airplane for the installation of radio equipment manufactured by the Nederlandsche Seintoestellen Fabrick (NSF) Co., Hilversum, Holland. This equipment will consist of a two-way communication set for telephone or telegraph, a radio compass for bearing direction and direction finding, and a five station interphone system.

The installation of this equipment is shown in Figure 70. Complete information on interconnections is given in the Radio Installation Wiring drawing listed in Appendix III.

A complete and separate system of conduits and junction boxes is provided for the radio to shield all interconnecting cables, wires, fuses, terminals, etc. Flexible conduits are fitted to units which are mounted on vibration shock absorbers and to other units in order to facilitate their removal from the airplane. All conduits are bonded to the structure of the airplane in accordance with U. S. Army Air Corps Specifications.

B. Operation

The radio operator has complete control of the communication, radio-compass, and interphone equipment. The communication receiver, transmitter, radio-compass receiver, and interphone amplifier are located in the radio compartment.

C. Power Supply

The radio and interphone equipment is supplied with power from the 12-volt electrical system. A 100-ampere fuse is inserted in the main positive supply lead, in a junction box located on the left-hand side of the airplane in back of the pilot. Other fuses are integral with various radio units.

D. Communication Equipment

This equipment consists of the following units:

1. Dynamotor "E"
2. Junction Box "B"
3. Transmitter "A"
4. Telegraph Key "D"
5. Junction Box "C"
6. Combined Receivers "F"
7. Dynamotor "S"

1. Dynamotor "E"

This unit supplies the low and high voltages required to operate the transmitter. It is located on top of the wing center section back of the pilot, and is connected to the electrical and radio systems by means of two flexible conduits. One of these flexible conduits is connected to a junction box ("Y") located near the dynamotor, containing the 12-volt positive and negative supply leads to the dynamotor. The other flexible conduit is connected to a rigid conduit which leads to the transmitter. The flexible conduits terminate at plugs which fit into sockets mounted on the dynamotor. This unit contains fuses which are readily accessible by means of a hinged door located above the plugs.

2. Junction Box "B"

This junction box is located in the radio compartment on the right-hand side of the airplane near the transmitter, and serves as a disconnect point for the transmitter-dynamotor connections. It is connected to the dynamotor by means of a rigid conduit and to the transmitter by means of a flexible conduit and plug. The plug is located on the bottom side of the box.

3. Transmitter "A"

This unit is located in the radio compartment on top of the wing center section in front of the radio operator. It is suspended from the structure of the airplane by means of rubber shock cords and is connected to the rest of the radio equipment by means of three plug-ended flexible conduits. The first flexible conduit connects the transmitter to the dynamotor at junction box "B". The second flexible conduit terminates at the telegraph key. The third flexible conduit connects the transmitter to the interphone system at junction box "J".

4. Telegraph Key "D"

5. Junction Box "C"

The telegraph key is located on top of the radio operator's chart table.

Junction box "C" is located in the radio compartment on the right-hand side of the airplane near the transmitter and serves as a disconnect point for the transmitter-interphone connections.

6. Combined Receivers "F"

The communication and radio-compass receivers are combined into a single unit located in the radio compartment on the left-hand side of the airplane. The lower half contains the communication receiving equipment. The receivers are mounted on vibration shock absorbers and are easily reached for tuning, adjusting volume control, etc.

The communication receiver is connected to the transmitter by means of a plug-ended coaxial cable. A plug-ended flexible cable connects the receiver to the rest of the radio equipment at junction box "J".

7. Dynamotor "S"

This dynamotor is located on the left-hand side of the airplane in the aft end of the radio compartment and furnishes plate voltage to the receiver. Snap fasteners and a plug-ended flexible conduit allow this unit to be quickly removed for servicing. Voltage filtering units and a quickly replaceable fuse are integral parts of this unit.

E. Junction Box "J"

This junction box serves as a main distribution point for all interconnections between the communication, radio-compass, and interphone equipment. It is located on the left-hand side of the airplane in the radio compartment and is easily reached for disconnecting the receivers, the interphone amplifier, etc.

F. Radio Compass Equipment

This equipment consists of the following units:

1. Dynamotor "T".
2. Receiver "F".
3. Loop "X".
4. Loop rotator "V".
5. Neon Tube Box "G".
6. Indicator-Pilot's.
7. Indicator-Radio Operator's.

1. Dynamotor "T"

This unit is located on the left-hand side of the airplane aft of dynamotor "S". Both dynamotors "S" and "T" are identical and are mounted on the same bracket.

Dynamotor "T" furnishes plate voltage to the radio compass receiver.

2. Receiver "F"

The radio-compass receiver occupies the upper half of combined communication-and-radio-compass-receivers "F."

The radio-compass receiver is connected to the loop by means of two plug-ended coaxial cables. A plug-ended flexible cable connects the receiver to the rest of the radio equipment at junction box "J".

3. Loop "X"

The loop is rotatable and is mounted on top of the fuselage forward of the radio operator and aft of the radio mast. The base is calibrated in degrees and a vernier attachment gives an accurate reading of the angle which the plane of the loop makes with the line of flight.

4. Loop Rotator "V"

This unit is located on the right-hand side of the airplane in the radio compartment within easy reach of the radio operator. It is connected to the loop by means of a flexible drive shaft.

5. Neon Tube Box "G"

This unit is located in the radio compartment on the left-hand side of the airplane and serves as a by-pass for radio frequency currents induced in the radio compass receiver antenna lead-in when the transmitter is in operation. It is connected on the forward side to the antenna mast by a heavily-insulated wire mounted on stand-off insulators. The aft side of the unit is connected to the radio compass receiver by means of a coaxial cable.

6. Radio Compass Indicator (Pilot)

7. Radio Compass Indicator (Radio Operator)

The pilot's indicator is located on his instrument panel near the flight instruments. The radio operator's indicator is mounted in a box equipped with vibration shock absorbers and is located in full view of the radio operator when seated at his station.

G. Radio Interphone Equipment

The interphone system will be a 5 station system which operates in conjunction with the radio equipment. Each station consists of a jack-box containing a microphone jack, a headset jack, and a volumn control. A signal light for attracting the crew members' attention is provided at the jack box with a push button for calling the radio operator.

The radio operator's interphone system is not complete on the Glenn L. Martin drawing but will be shown on the N.S.F. drawing. The connection of the interphone controls with the airplane equipment is, however, provided for.

The bomber's signal button and light are installed on the instrument panel as shown in Figure 60. The radio interphone system consists of the following units indicated on the radio diagram, Figure 70.

1. Interphone Amplifier "H"
2. Jack Box "N" (Bomber)
3. Jack Box "O" (Pilot)
4. Jack Box "M" (Commander)
5. Jack Box "L" (Rear Gunner)

1. Interphone Amplifier "H"

This unit is located on the left hand side of the airplane in the radio compartment and furnishes power to the 4 interphone jack boxes. It is connected to the radio equipment at junction box "J" by means of a flexible plug-ended conduit. The amplifier is equipped with jacks, volume control, etc., and serves as a jack box for the Radio Operator.

2. Jack Box "N" (Bomber)

3. Jack Box "O" (Pilot)

4. Jack Box "M" (Commander)

5. Jack Box "L" (Rear Gunner)

The Bomber's jack box is located on the left-hand side of the Bomber's compartment. The Pilot's jack box is mounted on the control column. The Commander's jack box is located to the right of the Operator, aft of the Radio Operator. The Rear Gunner's jack box is mounted on the rear control column.

H. Antenna System

The antenna for the communication radio equipment consists of two longitudinal wires located approximately 6 feet above the fuselage, running from a mast located approximately 24" ahead of the radio-compass loop to a fitting on the vertical stabilizer. The wires are maintained 5 inches apart in a horizontal plane by means of a spreader bar located on top of the mast and on top of the vertical stabilizer. The wires are insulated at each end by means of strain insulators and are connected together at the forward end only. Rubber shock cords at both ends of each wire maintain an even tension in the wires. The antenna lead-in wire drops from the forward end of the antenna to a lead-in insulator located on the left-hand side of the airplane.

The metal mast is insulated from the antenna system and from the fuselage and serves as the non-directional antenna required for the radio-compass equipment.

Provisions have been made for the installation of a transverse antenna consisting of a wire running from one wing tip over the mast to the other wing tip. Each wing tip is equipped with a chafing block on the top surface through which the transverse antenna may be threaded. A hook is located inside the wing for attaching the ends of the antenna.

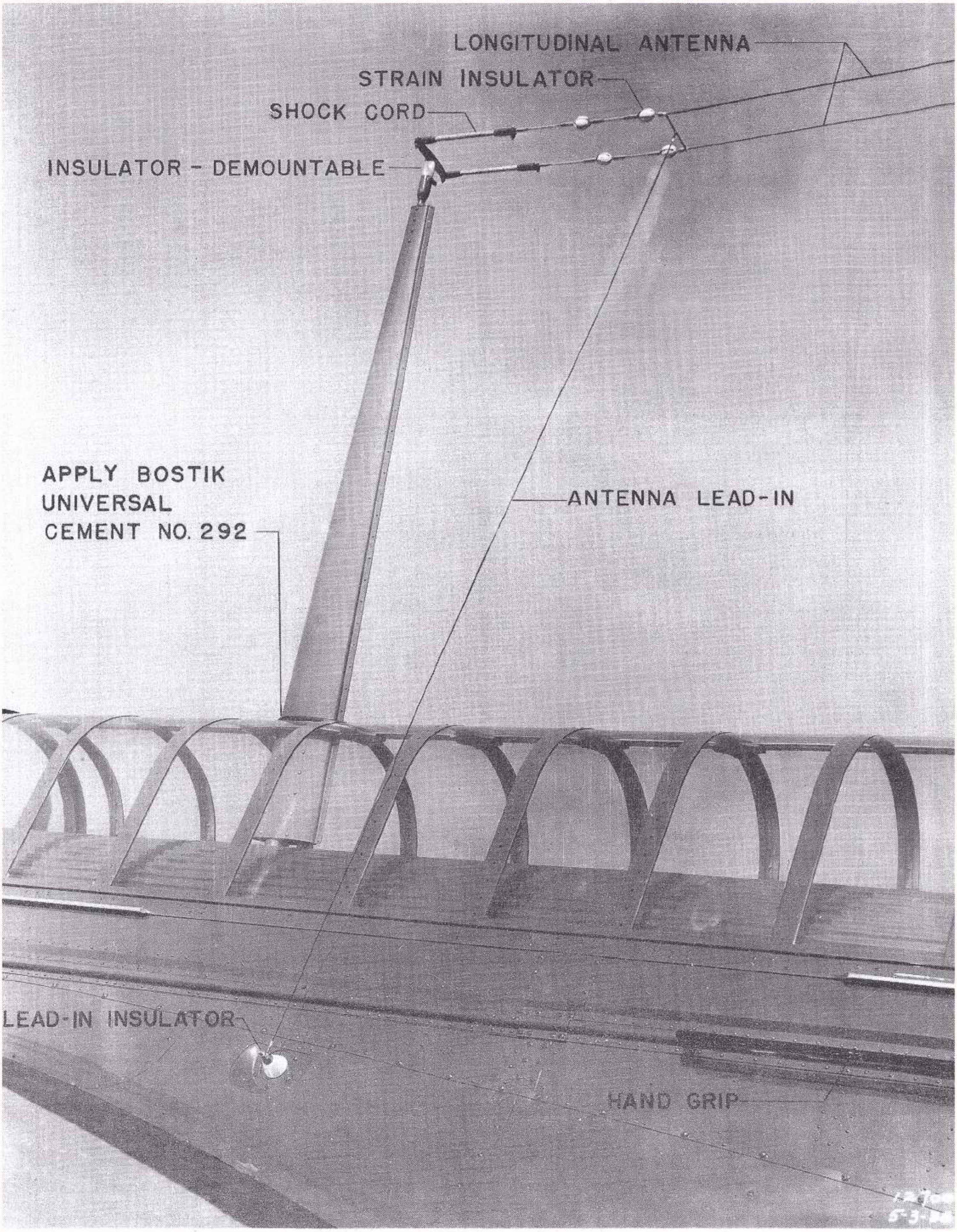


FIGURE 68 RADIO EQUIPMENT - EXTERNAL INSTALLATION

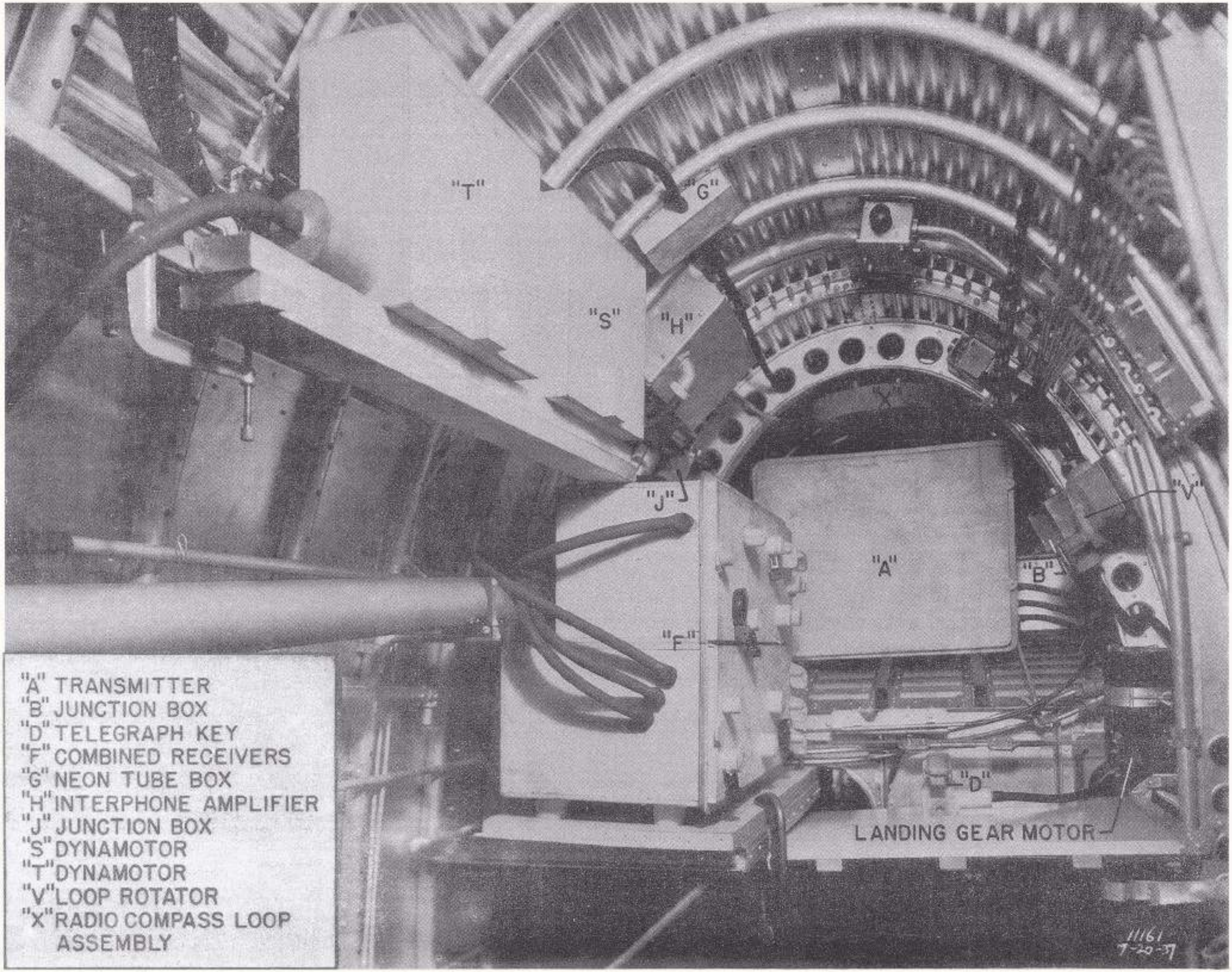
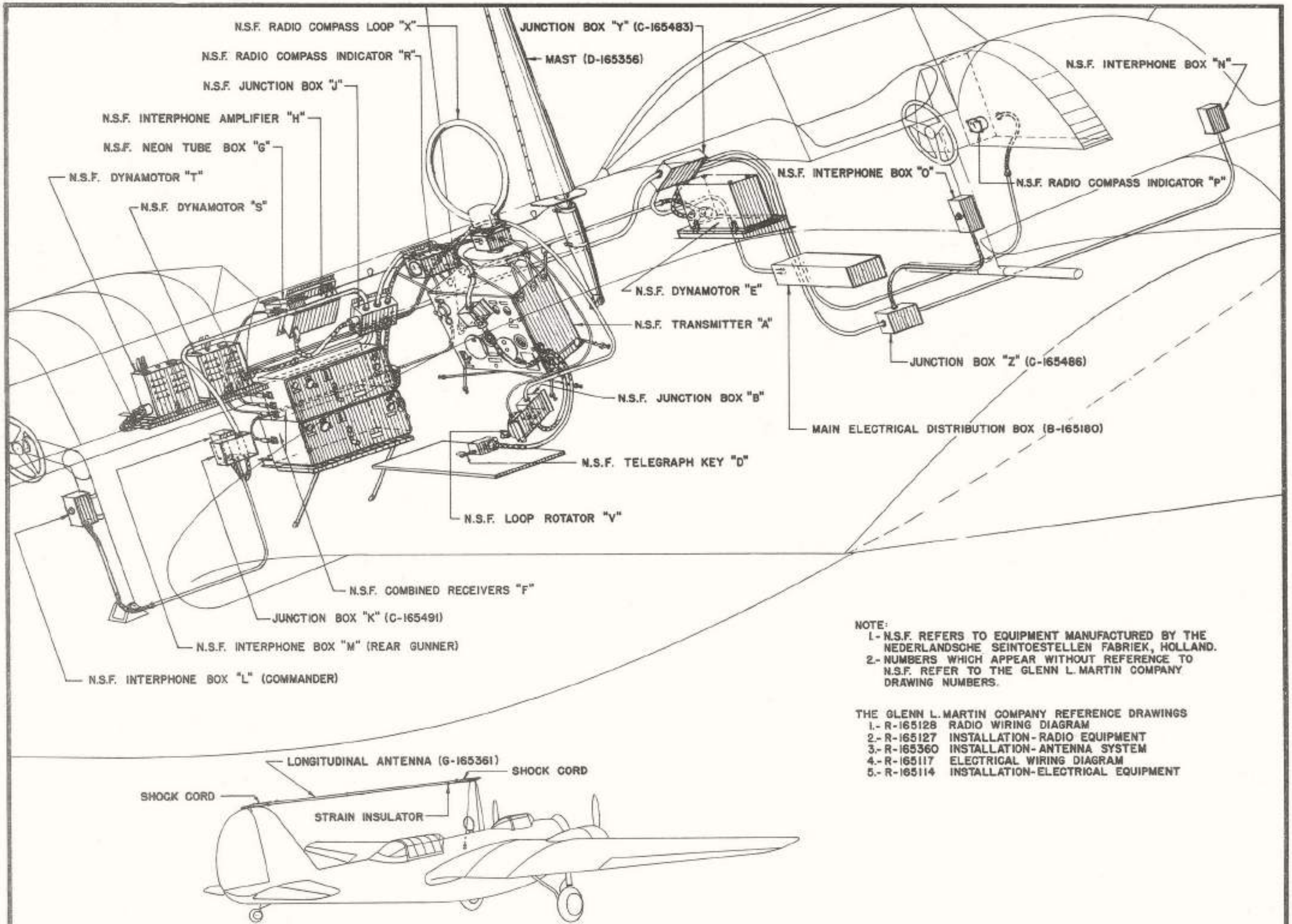


FIGURE 69 MOCK-UP OF N.S.F. RADIO INSTALLATION



NOTE:
1.- N.S.F. REFERS TO EQUIPMENT MANUFACTURED BY THE NEDERLANDSCHE SEINTOESTELLEN FABRIEK, HOLLAND.
2.- NUMBERS WHICH APPEAR WITHOUT REFERENCE TO N.S.F. REFER TO THE GLENN L. MARTIN COMPANY DRAWING NUMBERS.

THE GLENN L. MARTIN COMPANY REFERENCE DRAWINGS
1.- R-165128 RADIO WIRING DIAGRAM
2.- R-165127 INSTALLATION-RADIO EQUIPMENT
3.- R-165360 INSTALLATION-ANTENNA SYSTEM
4.- R-165117 ELECTRICAL WIRING DIAGRAM
5.- R-165114 INSTALLATION-ELECTRICAL EQUIPMENT

FIGURE 70 MODEL 139-WH RADIO INSTALLATION DIAGRAM

A-C

SECTION XXI

INSTRUMENT INSTALLATION

A. Descriptive List

Instruments are mounted on panels as follows:

1. Pilot's Cockpit (See Fig. 4A)

(a) Electrical Group

1 - Switch-Ignition, Scintilla Type AS-1202Z
1 - Switch-Voltmeter, Cutler Hammer #8210
2 - Switch-Ammeter, Westinghouse Type N.J.P., Style #70403
2 - Switch-Landing Lights, Cutler Hammer #8201K1
1 - Switch-Running Lights, Cutler Hammer #8208
1 - Switch-Airspeed Pitot Heater, Cutler Hammer #8201K1
2 - Switch-Starting, Eclipse M-2609, Dwg. C-20943
2 - Tachometer Indicators-Weston Model 545 with Tachometer Generator Weston 724-B
2 - Ammeters-Weston Model 506
1 - Voltmeter-Weston Model 506; 0-20 Volts
2 - Rheostat-Instrument Panel Lights, Model J-#0309 - with tapered winding (Ohmite)
2 - Rheostat-Compass and Nacelle Panel Lights, 50 Ohm-with snap switch (Yaxley)
2 - Switch-Curtiss Propeller for "Manual-Automatic" Operation, Cutler Hammer #8201K1
2 - Switch-Curtiss Propeller; for "Increase-Decrease" Control, Cutler Hammer #8212
2 - Switch, Safety-Curtiss Propeller, General Electric #GB130

(b) Flight Group

Airspeed Indicator (Special-Pilot only)	Kollsman Type 157-097
Altimeter	Kollsman Type 134B-031
Bank and Turn Indicator	Pioneer Type A-385-E
Compass (Magnetic)	Kollsman Type 58-BL
Clock	Kollsman Type 133-01
Rate of Climb Indicator	Kollsman Type 164-08
Thermometer (Air)	Kollsman Type 95-01
Synchroscope	Eclipse Type M-3254

(c) Miscellaneous

Fuel Quantity Gauge	Liquidometer #AC-147
Switch Assembly, selector	Liquidometer EA-40B
Primer	Parker #4051, Type A
Directional Gyro Control Unit	Sperry #641866
Bank and Turn Gyro Control Unit	Sperry #641865
Mounting Unit (on pilot's instrument panel)	Sperry #643144
Speed Control Valve	Sperry #641843
Oil Pressure Gauge	Sperry #150003

(c) Miscellaneous (continued)

Manifold Block	Sperry #88908
Vacuum Relief Valve	Sperry #641240
Manifold Pressure Gauge	Kollsman Type 62-03
Fuel/Air Ratio Indicator Dual Dial	Cambridge S.O. 54244
Fuel Pressure Warning Unit	Pioneer Type 1173

2. Bomber's Cockpit

Airspeed Indicator	Kollsman Type 157-03
Air Thermometer	Kollsman Type 95-01
Altimeter	Kollsman Type 134B-031
Compass-Magnetic	Kollsman Type 58-BL
Clock	Kollsman Type 133-01
Switch Assembly, Utility, Panel Lights	Cutler Hammer #8201K1
Switch, Airspeed Pitot Heater	Cutler Hammer #8201K1

3. Co-Pilot's Cockpit

Airspeed Indicator	Kollsman Type 157-03
Altimeter	Kollsman Type 134B-031
Compass (Magnetic)	Kollsman Type 58-BL
Clock	Kollsman Type 133-01
Turn and Bank Indicator	Pioneer Type A-385-E
Rate of Climb Indicator	Kollsman Type 164-08
Switch Assembly, Utility, Panel Lights	Cutler Hammer #8201K1

4. Engine Nacelles

Fuel Pressure Gauge	Kollsman Type 130-03
Oil Pressure Gauge	Kollsman Type 131-05
Oil Temperature Gauge	Kollsman Type 30-04
Thermocouple (Engine Temperature) Gauge	Weston 602, Type 43

B. Air Speed Heads (Kollsman Type 171-B)

An airspeed head is mounted on the right-hand wing for the pilot's indicator and one on the left-hand wing for the bomber's and copilot's instruments. The rear instruments may be drained at the rear of the bomb bay by removing a plug in the "Tee" fitting. A similar fitting at the front wing spar drains the line to the pilot's instruments. One switch on the pilot's switch panel and one on the bomber's instrument panel is provided to close the heater circuits to the heads. They should be "ON" in flight if ice conditions are prevalent but should be turned "OFF" when not needed.

C. Instrument Panels

The instrument panels are mounted with "Lord" rubber shock mounts and all are indirectly lighted. The pilots' panel consists of a deep box to the face of which are fastened the individual sub-panels containing the instruments. These sub-panels are attached by means of "Dzus" flush-type fasteners to facilitate removal. The other panels are sub-panels to which the instruments are bolted. A cover panel for reflecting light onto the instruments is provided. The "Acorn" nuts and lamp socket covers must be removed to gain access to the instrument mounting screws. The pilots' panel box is removed by disassembling the shock absorber units and removing the rudder support tube.

Clear lamps are used in the pilot's panel and the engine nacelle panels. Use 12-16 volt, 6 C.P., "G-6", clear, bayonet candelabra base, double contact lamp when it is necessary to replace the lamps in the pilot's panel and use 12-16 volt, 3 C.P., "G-6", clear, bayonet candelabra base, double contact lamp when it is necessary to replace the lamps in the nacelle panels. (NOTE: Two light assemblies with clear 3 C.P. lamps are provided for the purpose of lighting the gyro instruments that are installed in place of the automatic pilot panel on some models. The automatic pilot has built-in lighting).

The lamps for the electrical panel in the pilot's cockpit, the emergency pilot's panel, and the bomber's panel are green. When replacements are necessary, use 12-16 volt, 2 C.P., "T-4½", green, bayonet candelabra base, double contact lamp. Spare lamps for the pilot's instrument panel are carried in a small box on the right side of the pilot's cockpit.

D. Vacuum System

1. General

The pilot's turn and bank indicator and the Sperry Gyropilot, and the co-pilot's turn and bank indicator are all operated by two vacuum pumps, one located on each engine. The pumps are attached to the engines by means of special mounting pads which are provided with an .040 diameter orifice in the base fitting for internally lubricating the pumps. The installation of the vacuum pump and its relief valve is shown in Figure 65A. The discharge from the vacuum pump is exhausted overboard through a drain tube also shown in the above Figure. It is essential that the drain line be kept open at all times.

The vacuum lines from both pumps are connected to a selector valve located on the lower left corner of the auxiliary control panel at the pilot's right (see Fig. 4A). An emergency suction relief valve adjacent to each pump prevents excessive loads on the pump. A check valve is provided in each line between the pump and selector valve to maintain suction if either pump should fail, and also to protect the delicate gyroscopic instruments from pressure lubricating oil which may back up into the line in case of failure of a vacuum pump. As an additional precaution, the selector valve provides a positive shut-off in the line to the inoperative pump. This valve should be turned to "Both On" except in the case of a pump failure.

The pilot's gyro instruments and the turn and bank indicator are connected to the selector valve through a relief valve which is located on the panel at the right side of the pilot's cockpit. A suction gauge is provided on the panel adjacent to the bank and climb gyro and is connected to the supply line. The desired vacuum reading at this gauge is 4 inches (10 cm.) of mercury. It should not be less than 3 inches or more than 5 inches. The vacuum is adjusted at the relief valve adjacent to the instruments. The engines should be run at 1100 r.p.m. to make this adjustment. The vacuum pump relief valves at the engines are adjusted t maximum output by screwing the adjusting nut out. The relief valve in the pilot's section is adjusted to maximum output by turning the adjusting screw in.

Adjusting the vacuum is described under "Vacuum System", paragraph J-3, Section XVIII.

2. Turn and Bank Indicators

The pilot's and copilot's turn and bank indicators are installed with a special nipple No. 127300 in the fitting adjacent to the instrument. A small orifice is drilled through the restriction in the nipple to provide 2 to $2\frac{1}{2}$ inches of suction. This orifice varies with each instrument. It is recommended that the nipple assembly be kept intact with the indicator if replacements are made.

Since the instrument is calibrated for a pressure difference of two inches of mercury, it is advisable after every installation to check the suction by means of a suitable vacuum gauge attached to the connecting tee. A pipe plug is provided in the tee for this purpose. The engines should be run at 1100 R.P.M. for the check.

It is important that the line be thoroughly cleaned by blowing through after any additional regulation of the orifice. The line must be disconnected between the relief valve and the indicator when cleaning.

Caution: NEVER BLOW INTO ANY VACUUM INSTRUMENT.

3. Airspeed Indicator

The pilots' airspeed indicator (Kollsman Type 157-097) is especially calibrated to read accurately with the pitot head installation on the right hand wing. Since the accuracy of the airspeed reading depends upon the location of the head it should be noted that the indicator will not read correctly if changed to operate from a head located in a different position. For the same reason, the indicator cannot be used in another airplane.

E. Maintenance

The instrument lines may be identified by referring to the chart in paragraph E, Section II-B. Drain plugs are provided at the lowest point in the necessary places for removing condensate. Breeze "Aeroflex" type hose is used to connect the pipe lines to the instruments thereby reducing the possibility of failure at the instrument connection. These points should be kept tight, but need not be checked except when the instrument reads faulty or at overhaul periods.

Instruments should be calibrated at regular periods in accordance with standard practices, and the lines checked for leakage if the readings are not correct. Check the operation of the electrically heated pitot heads particularly during operation in ice forming weather to be sure the heater elements are not burned out.

Additional maintenance of instruments consists of keeping the pipe line clamps secure, replacing burned out lamps, and of keeping the dials and crystals tight. See the list of instruments bulletins in Appendix II for further checks.

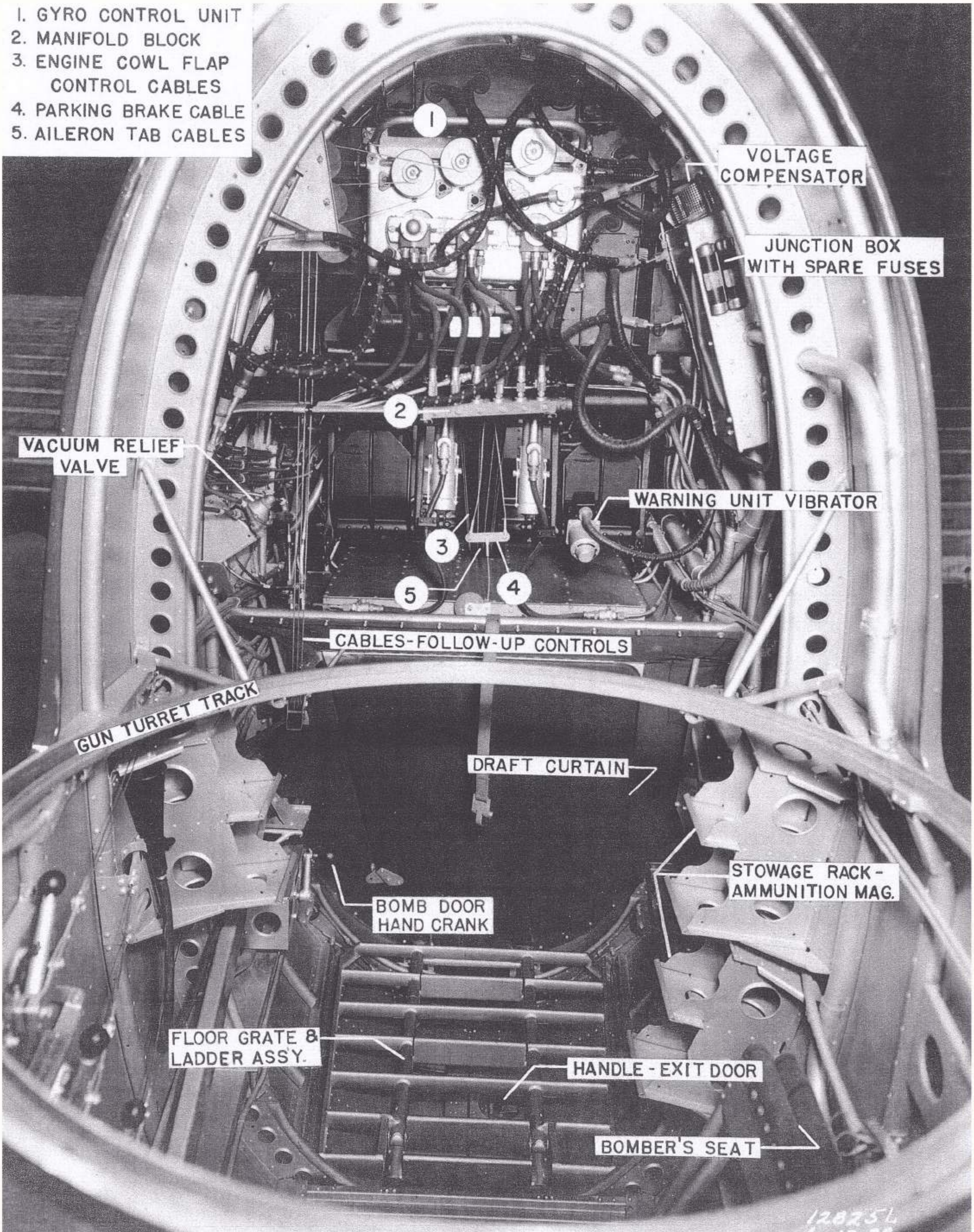


FIGURE 71 PILOT'S INSTRUMENT PANEL - FROM BOMBER'S COMPARTMENT C

SECTION XXIII

INSPECTION PROCEDURE

A. General

A conscientious adherence to the following inspection instructions should assure long and satisfactory service from this airplane. The miscellaneous accessory booklets mentioned should be studied for detail inspection procedure, and such instructions as are necessary should be included with these lists covering Pre-Flight, Daily, 20 hour and 40 hour inspection.

It should be noted that many items contained in the following instructions can not be thoroughly inspected without disassembly and that a visual inspection only of such parts will be possible during Pre-Flight and Daily Inspection. Where a more complete inspection is required, mention is made herein, or in the bulletins covering accessory equipment. In any case where the malfuntioning of any item is apparent during ground testing or flight, a complete inspection should be made before the airplane is again flown. Disassembly of instruments is generally prohibited unless specific orders to the contrary are given by the Officer in Charge, and where specially-trained mechanics are available for such work.

Whenever possible, the daily inspection should be accomplished immediately after the last flight for any one day, particularly in connection with refueling since filled fuel tanks are safer than partially-filled tanks. Refueling should be done out-of-doors after attaching "grounding wires" to the fuselage structure. Suitable fire extinguisher equipment should always be available.

Detailed instructions for starting, warming up, and stopping the engines are contained in Section II A of this manual and in the Pilot's Manual. Instructions should be closely adhered to by any personnel operating the engines on the ground since any deviation therefrom may cause considerable damage to the airplane and its accessories.

Notes on the heating of oil and on the use of starters during extreme cold weather are contained in paragraph "C" of the Pilot's Manual.

At the termination of flying for any one day or on return to the hangar on completion of a cross-country flight, check the log books for airplane and engine for trouble notes in order that any malfunction of parts be remedied before the next flight.

B. Pre-Flight Inspection

Make a visual inspection of the airplane to ascertain the normal condition of the landing gear, engine and nacelle cowling, radio antennae, conditions of wing tail, and flight control surfaces, cleanliness of windshields, and security of doors and similar parts. Test the complete operation of all flight controls to see that they operate freely. Inspect the interior of the fuselage to see that nothing is left loose that is apt to jam the controls. Test the operation of the wheel brakes and flap controls. Operate the bomb doors and the cockpit enclosures to see that they function properly. See that the fire extinguishers, flight report forms, log books, and data cards are in place. Check the quantities of fuel and oil in tanks and see that the caps and drain fittings are secure. Make a visual inspection of these systems to note if there is evidence of leakage outside the airplane. Test the oxygen supply pressure (if system is installed). Operate the engine cowl flaps and the carburetor pre-heater control. Turn the propeller over by hand four revolutions before starting the engines. See Pilot's Instructions to start and warm up engines.

During engine warm-up, check the following (see Section II-A for instrument readings):

Switches - Lights, Generator, Starter, Magnetos and Propellers.
Ammeter (See Part S, Section II-A).
Voltmeter (See Part T, Section II-A).
Pressure Gauge - fuel and oil.
Fuel Quantity Gauge - switch to all tanks.
Thermometers.
Tachometers - operate propeller governor controls to check.
Clock - wind up (and set).
Altimeter - check barometric pressure with station instrument.
Fuel/Air Ratio Indicator - (See Section II-A, paragraph M, Pilot's Instructions).
Automatic Pilot - (See Section II-A, paragraph N, Pilot's Instructions).
Test the operation of all fuel valves and see that they are properly set for take-off. (See Section II-A, paragraph D, Pilot's Instructions).
Propeller Operation - (See Curtiss Installation and Maintenance Instructions).
Supercharger Operation - (See Eclipse Booklet).

Check through the items in paragraphs C, D, and E of the Pilot's Instructions, checking off any not already inspected.

C. DAILY INSPECTION	TWENTY HOUR INSPECTION	FORTY HOUR INSPECTION, ETC.
(See Airplane and Engine Log Books for trouble notes on last flight.)	The Twenty Hour Inspection shall include all items in the Pre-Flight and Daily checks and in addition shall include the inspection procedure in this column.	The Fourty Hour Inspection shall include all items in the foregoing inspections in addition to this column.
1. Fuselage		
Check general condition and inspect for bumps, tears, or cuts in the metal covering. Inspect for deformation of covering that might indicate broken structural members. Check internal bracing, longerons, and fittings, and the security of internal equipment. Check the operation of all doors and the security of access hole covers. Check operation of nose turret	Inspect mechanisms for operating Bomb Bay doors. The vertical screw and parts of the split-nut mechanism should be oiled every 20 hours with thread Lubricant. (See chart in Appendix IV.)	Make complete and rigid inspection of condition. Thoroughly clean the inside of the fuselage. Inspect all accessible parts for condition. Inspect for cracks around Plastacelle windows. Replace any damaged parts with same material. Inspect bottom of fuselage for holes and cracks. Make repairs if necessary in accordance with Appendix I.

1. Fuselage (Cont.)		
and the cockpit inclosures, clean windows, and repair if necessary. Drain any accumulated water and remove any foreign items (such as empty cartridge cases) likely to jam the controls.		
2. Cockpits		
Check the general condition and cleanliness. Operate such controls as can be safely operated on the ground. Check seats for security and proper functioning of the adjusting mechanism. Inspect safety belts and fastenings. Check fire extinguishers for general condition.	Make a complete and rigid inspection of the condition. Inspect safety belt fabric, catches and buckles.	Make weight tests for safety belts. Grease pilot's seat. Inspect retracting mechanism in cockpit.
3. Instruments		
See that the altimeter reads correctly by checking with the station barometer. Check the general condition-such as loose dials and misaligned pointers, broken crystals and broken tubes and lines. Tubes may be traced by means of the colors painted thereon. (See Par. D, Section II-B.) A check of the proper functioning of instruments is a part of the Pre-Flight check.		Remove and clean jet cover of turn and bank indicator every 100 hours. Lubricate every 300 hours. Inspect altimeters. Remove and make complete bench test every 300-400 hours. Calibrate instruments, particularly compass. Check operation of electrically-heated pitot tubes and replace any burned-out heating element. Drain tubes as required. Check Automatic Pilot. (See Instruction Book for detailed inspection.)
4. Flight Control Surfaces		
Check the ailerons, elevators, rudder, and all trim tabs for general condition of their covering and security. Check for full operation of all controls and make a general visual check of cables and push-rod controls.	Make a complete and rigid inspection of operation and condition.	Inspect metal covering for damaged sections. If shakes have developed in vertical or horizontal stabilizers check hinge bolts for tightness. Fairing must be removed to gain access. Remove drain plugs located in flotation compartment of horizontal stabilizers to allow any condensation to drain out. See that vent tubes are not plugged up. Check security of all bonding

4. Flight Control Surfaces (Cont.)		
		Remove tail fairing to inspect Empennage Control Cables and Quadrant. Remove Guard (Sta. 4) to inspect Control Cables and Quadrant.
5. Engine Controls		
Check the general condition and proper functioning of the throttle, and mixture, control levers, the carburetor pre-heater control, and engine cowl flaps. (Detail check of functioning of controls is made during Pre-Flight check.) Check super-charger regulator controls.	Make a complete inspection of entire linkage for: Free and full movement, lost motion, condition of cables and rods, proper safetying, adjust Ball-and-Socket joints, lubricate as required.	
6. Ignition & Electrical		
As part of the Pre-Flight "warm up", check function of Starter and Booster, Ignition System, Generator, and Generator Control Unit. Check interphone signal system. Inspect cockpit lights. Inspect instrument lights and rheostats. Check landing lights and navigating lights. See that the spare bulbs and fuses are supplied. Check spark plugs.	Inspect magnetos, (see Instruction Book for Wright Cyclone Engines.) Inspect spark plugs twice each 20 hours at 10-hour intervals for loose center electrodes, etc. (See Wright Engine Book.) Inspect Generators and Control Units for security of mounting, cleanliness of unit, and condition of contact points. Inspect security of bonding.	Inspect all wiring for condition of insulation and proper anchorage. Inspect starter for security of mounting, tightness of housing bolts, condition of brushes, brush holders and commutator, and tension of brush springs. Remove, disassemble, and test spark plugs. Inspect magnetos for backlash in distributor gear; lubricate as required. Inspect booster coil and vibrator assembly for proper operation. Inspect all switches and rheostats. Check lights, throughout airplane.
7. Fuel System		
Drain all fuel line strainers and resafety drain cocks. With fuel valve "ON" operate wobble pump until normal operating pressure is obtained. Look for evidence of leaks in fuel system. Check all fuel cocks for free operation. Test fuel quantity gauge. Inspect cable connections to bomb bay auxiliary tank Release mechanisms.	Remove engine cowling. With fuel "ON" operate wobble pump and make complete inspection for leaks cracks, wear, security of anchorages. Remove and clean strainers. Lubricate carburetor throttle shaft bearings and exposed operating parts of economizer and accelerating pump. Check condition of hose connections. Drain carburetors and clean strainers. Grease flexible	Lubricate entire fuel pump drive shaft. Inspect condition of hand refueling pumps and primer. Inspect fuel cock controls for excessive backlash or drag. Every second 40-hour inspection remove and drain carburetors. Clean intake screens. Make rigid inspection of fuel tanks for leaks, condition of mountings, and bracing, every second 40-hour period (unless fuel tank doors are

7. Fuel System (Cont.)		
	coupling on fuel pump.	otherwise removed). Inspect auxiliary tank release mechanism. Inspect security of all electrical bonding.
8. Oil System		
Inspect for evidence of engine throwing oil. Turn Cuno Strainer handles one full turn in counterclockwise direction. After each oil change remove and clean Cuno strainer. Check security of drain cocks and plugs. Make visual inspection of oil system for leaks. Inspect oil coolers for leaks and for security of attachment.	Make a complete inspection of lines for leaks and cracks, security of anchorage, condition of rubber. Inspect condition of cooler. (See Wright Engine Book.)	Make rigid inspection of tanks for leaks and for condition of mounting and bracing. Operate all drai lines. Check condition of oil coolers and the setting of temperature regulators. Clean Cuno Strainer. Inspect all lines for condition of hose connections and secu ity. Note presence of leal around engine or excessiv throwing of oil. Check condition of electric oil heaters (if installed).
9. Power Plant and Accessories		
Check manifolds for security of attachment and blown gaskets. Inspect exhaust stack studs for tightness. Check security of carburetor pre-heater. Check security of exhaust gas analyzer nipples and lines. Check the security of the starter, generator, oil pump, fuel pump, carburetor, etc. Make a visual check of the cowling supports and the muff for security of attachment. Refer to the Wright Instruction Book for engine inspection procedure. Check super-charger regulator.	(See Wright Instruction Book.)	Make complete inspection of valve mechanism including check of valve clearances in accordance with Wright Instruction Book. Inspect push-rod and tappet adjustment screws. Check condition of intake and exhaust pipes and manifolds. Clean exhaust stacks and check for cracks. Inspect engine mount completely for security and general condition. Check general condition of cowling supports. Make thorough check of electrical bonding and shielding.
10. Propellers and Accessories		
Clean blades and hub with a clean cloth soaked in kerosene or gasoline, dry thoroughly, and coat with light engine oil. Check general condition and security of retaining nuts & blades. Remove brush housing and check condition of brushes. (Electric Props).		Propellers should be removed, disassembled, cleaned, and inspected approx. each 6 months. Propellers should be given major overhaul each 100 flying hours. Disassemble brush housing and thoroughly inspect condition of brushes and slip rings. Check operation of propeller

10. Propellers and Accessories (Cont.)		
Check operation of switches and speed control as a part of Pre-Flight inspection. Check blades for nicks and dents. Greese every 10 hours. (See Propeller Manuals.)		governor and controls, (on electric propellers) and lubricate as required. See Manual for additional instructions.
11. Landing Gear		
Check tire pressure. Check general condition of Oleos and inspect for evidences of leaks around top. Check retracting cables for wear. Check struts, fittings and attaching parts for cracks and loose connections. Check brake operation. (It should not be "soft." Brake-pedal movement should be equalized and not excessive.) Inspect tires for proper inflation and for cuts or excessive wear. Check tightness of wheel bearings by rocking airplane. Check track for loose stones or mud which would not permit trolley to move freely.	Make thorough check for condition and security of struts, bracing, and fittings. Lubricate strut bearings and moving parts. Check fluid level of Oleos Check retracting motor. (See Eclipse Book.) Check proper extension of Oleo struts. Fill only with COMPRESSED AIR. Inspect brakes and control assembly without removing wheels. Adjust brake clearance. Check fluid level in brake reservoir. Inspect lines and connections for leaks, kinks, and damaged parts. Check for deteriorated valve insides and cap seals (Oleos and tires).	When practicable and when considered necessary, remove load from the landing gear and make complete and close inspection for wear, cracks, etc.; and for proper functioning of retracting mechanism. Inspect all the cables thoroughly, also limit and control switches in bomb bay. Disassemble retracting motor and gear mechanism every 300 hours to ascertain condition. Repack with Penola No. 4 Lubricant. Remove wheels and inspect brake mechanism for worn or scored drums, corrosion, worn brake lines, distorted shoes and backing plates, and proper spring tension. See that brake bands are free from grease. Check rivets and bolts for tightness. Check condition of protective coating. Clean, inspect, and lubricate roller bearings. Reinstall wheel, adjust brakes, and check wheel for side play. See Warner Instructions for servicing brakes and controls. Inspect condition of main retracting cables and security of attaching links and operating pulleys. Check vibrator warning device.
12. Tail Wheel		
Check Oleo shock unit for proper extension. Inspect attachment of wheel and shock unit for security. Inspect tire for cuts and excessive wear. Remove mud, grass, and excess grease. Check tire pressure.	Make rigid inspection of condition. Check operation of swivel release mechanism. Lubricate as provided for. Check for leaking valve inside or valve cap.	Disassemble tail wheel from axle. Inspect bearings. Clean, lubricate, and reassemble.

13. Wings		
Inspect general condition of covering and paint. Check all access doors for security. (Maintenance of the wing proper consists of keeping the finish and covering in good condition. Wing should be walked on only where painted black; other places must be heavily padded to protect ribs and skin covering from damage when walked on.)		Make complete and rigid inspection for condition and security of attachment fittings. Remove drain plugs from flotation compartment to allow any condensation to drain out. See that vent lines are open.
14. Armament		
All parts should be inspected as necessary, depending on their use. The safety locking device should be checked for proper functioning prior to daily operations when bombing equipment is being used. The rack operates both mechanically and electrically and should be checked to insure positive action. Caution: The bomb rack and control mechanism should not be greased or oiled at any time while the racks are in use as this may cause dirt to accumulate and result in malfuntioning of the rack. When necessary to clean, use Kerosene. Thoroughly clean prior to loading of bombs or conducting bombing missions. Check gun mounts for security each day during gunnery operations.	Check complete operation of bomb rack both electrically and manually to ascertain proper functioning. Check indicator system in bomber's cockpit. Replace used spare bulbs.	
15. Oxygen System		
Prior to each flight during which oxygen is to be used, inspect the equipment for security of supply cylinders and operating handles, valves, bayonet connections and heaters. Test supply pressure and replace bottles if necessary. Caution: Do not use oil around this equipment, as spontaneous combustion may result.		

16. Night Flying Equipment		
Check funtioning of lights. When installing parachute flares, make complete inspection of flares and of carrying and release mechanism. Check installation of proper signal flares and see that the Signal Pistol is in the airplane.	Remove installed flares and inspect them for condition. Check release system. Replace signal flares as required. Make additional checks in accordance with daily inspections. Important: Oil or grease should not be used at any point of the cable release system. Doors and hinge should be checked carefully to be sure that they are not stuck due to corrosion.	Make complete inspection of flare racks and flare releasing mechanisms.

17. Airplane in General (40 Hours , etc.)

Remove, inspect, and weigh all carbon dioxide (CO_2) cylinders. Make annual inspection of complete fire extinguisher. Remove and pump up life raft for inspection every four months (test pump). Inspect bonding and shielding for installation and condition, security of contacts, broken or frayed shielding, and ground leads. Check condition of curtains.

18. Battery Inspection (Weekly)

Check security of mounting and condition of container. See that drain tube is not obstructed. Check leakage due to broken case or defective sealing. Check condition of leads and installation, security of terminals. Remove any dirt or corrosion. Coat terminals with Vaseline. Check specific gravity of each cell (record lowest cell reading). Add distilled water as necessary. Test battery switch. Refer to Exide Booklet for further details.

19. Engine Change

Comply with all current technical instructions requiring special inspections or maintenance work at time of engine change. See Wright Instruction Book. Ground test and flight test newly installed engines in accordance with standing instructions. Clean Cuno Oil Strainer at the expiration of the engine installation, and run-in prior to flight, and again at the completion of necessary test flights before the engine is released for service. Check for loose or deteriorated rubber engine mount bushings, and replace where necessary. Check for distorted fuel lines or other indications of possible switched "main" and "reserve" lines at tank connections.

GENERAL REPAIR OF

STRESSED SKIN STRUCTURES

(Insert as Appendix I of Maintenance Manual)

Engineering Report No. 432
February, 1936.

The Glenn L. Martin Company
Baltimore, Maryland.

Prepared by (S) M. Maxfield

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Chief Engineer

(Re-issued without change
9/13/37 - J. S. S.)

REPAIR OF STRESSED SKIN ALUMINUM ALLOY STRUCTURE

In case of a hole or other damage to a stressed skin of this type, the first step is to remove all the damaged material, and at the same time leave the outline of the hole with a smooth contour free from sharp corners. This point is illustrated in the sketch opposite, where a jagged tear is cut out to a smooth hole.

Next a patch plate must be put over the hole. The thickness of this plate must not be less than the sheet to be repaired, and in very thin sheets it is best to make the thickness one gauge larger. It should extend on each side of the hole a sufficient distance to get a good riveted connection along the sides. This is to reinforce the hole against edge failure. It should also extend in front and behind the hole far enough to permit the driving of sufficient rivets to carry the load.

It is necessary to put enough rivets ahead of the hole to pick up the entire load that was formerly carried by the material removed. Usually the maximum allowable stress is assumed to be acting, and the rivets designed for this load. The same number of rivets must be placed to the rear of the hole to transmit the load back into the skin on the rear side.

It is often necessary to cut small holes in stressed skin for cables, wires, pipes, etc. To reinforce these, a series of standard circular reinforcements have been designed and are shown on one of the following sheets.

As each repair job offers a separate problem, it is impossible to work to any standards. The following pages present several typical repairs and the methods used.

I Repair of Corrugated Skin Covers.

In the repair of breaks in all corrugations, the corrugations are assumed to be subjected to a stress equal to the crippling stress. This is used to determine size of reinforcing plate and number of attaching rivets required.

A specific example is given in Fig. 1 to show the methods of repairing a break in corrugated skin.

Assume .051 gauge corrugated skin.
Assume stress in corrugated skin equals 40000 lb/sq. in.
Reinforcement should be at least the gauge of the corrugation or preferably one gauge heavier.

A

Area removed equals 1.228 x 2.5 x .051 which equals .155 sq. in.
Load in Reinf. equals .155 x 40,000 which equals 6200 lbs.
Allow. Bearing 1/8 rivet on .051 equals 477 lbs.
Allow. Shear 1/8 rivet equals 369 lbs.

No. rivets required equals $\frac{6200}{369}$ equals 17

A minimum of 17 rivets should be used in front and behind break to attach reinforcing to corrugation.

II. Repair of Smooth Skin Covers (*)

In smooth skin structures the maximum allowable tension stress is reduced to 43600 lb/sq.in. to account for reduction in area due to rivet holes. All skin is assumed to be subjected to this stress.

In structures with thin skin the reinforcement plate should always be at least one gauge heavier than the damaged skin. As the size of break increases, this difference in gauges should increase accordingly.

A specific example of smooth skin reinforcement is given below.

Assume skin gauge equals .028
Assume skin stress equals 43600 lb/sq.in.
Area removed equals .028 x 2.5 which equals .07 sq.in. — See Fig. 2
Load in reinf. equals .07 x 43600 which equals 3050 lbs.
Allow. bearing 1/8 rivet on .025 equals 237 lbs.
Allow. shear 1/8 rivet equals 369 lbs.

No. rivets required equals $\frac{3050}{237}$ which equals 13

(*) This type of repair only for smooth skin which carries stress. Does not apply to top skin on corrugations, cowling, fairings, etc.

A minimum of 13 rivets should be used in front and behind break to attach reinf. to skin.

III. Standard Reinf. for Small Holes in Thin Sheets

The reinforcements shown in Fig. 3 are to be considered standard for round holes up to one inch in diameter in stressed thin sheets.

Whether the reinforcement washers are single or double will depend on the nature of the stress, vibration, etc. in any case the thickness of each washer shall be at least equal to the thickness of the sheet.

Repair of Trailing Edge - Fabric Covered Surface

In the case of a damaged trailing edge strip, the method of repair is comparatively simple. The damaged portion is cut away. It is usually most convenient to make the extremities of the cut centrally between trailing edge ribs. This permits the splice clips for attaching new section to be installed easily.

Fig. 4 shows a typical method of splicing ends of trailing edge strips.

Note: Fabric to be repaired according to standard methods.

Repair of Fuselage Side Skin

The repair of the side skin if only a crack appears is a little different than the repair of a hole. In this case it is not necessary to clean a smooth hole the full length of the crack. However, it is important that a small round hole be drilled at each end of the crack. These holes will tend to prevent the crack from spreading and thus, insure a better repair job. The method of finding the number of rivets required and size of patch plate is the same as the one used in preceding discussions for smooth skin.

Fig. 5 illustrates this type of repair.

Repair of Damaged Skin in Flotation Compartment

Damaged skin in this compartment is repaired in the same manner as previously discussed for smooth skin repairs, also corrugated skin repairs. Besides being strong enough to carry the necessary load, patches in this compartment must also act as seals. This is done by putting sealing compounds under the patch and using a water-tight rivet spacing around the edge of the patch.

Fig. 6 illustrates this type of repair.

Repair of Metal Nose Cover on Flaps

The repair of this nose cover requires the removal of all fabric adjacent to the damaged portion. The size of this cover plate prohibits the use of hand holes as an aid in attaching the repair sheet. The simplest method is to remove a complete section of the nose cover and installing a new one. Lap splices should be made at nose rib, this insures a rigid joint. Tools for bucking the attaching rivets may be inserted between the torque tube and the short side of the nose cover. The gauge of the repair sheet should be the same as the original nose cover.

Fig. 7 illustrates this type of repair.

Repair of Metal Covered Stabilizer

In this type of structure all sections are completely closed making any repair to the skin rather difficult. Breaks in the skin that can be cleaned out to hole of not over 5" in diameter can be repaired by installing a standard hand hole. The hole should be reinforced by attaching a heavy ring on the inside of the skin. This ring should be about two gauges heavier than the skin. The cover plate should be at least the gauge of the skin, a gauge heavier is preferable. The cover plate must be screwed on, requiring the installation of elastic stop nuts, or the provision of tapped holes in the reinforcing ring. The use of elastic stop nuts is usually most convenient.

In case the damage is too large to repair by means of a hand hole, the entire panel may have to be removed, or at least a large portion of it. If the entire panel is replaced, the new panel should be riveted to the front spar first. This permits the rear end to be raised, and the introduction of bucking tools through the opening to aid in riveting a hand hole may be assembled on the repair plate before the plate is attached to stabilizer.

If only a portion of the panel is removed, the transverse splice should come at a skin stiffener. A hand hole may also be incorporated in this repair plate if desired. Method of attachment to be the same as that for entire panel repair.

In case any of the above repairs are necessary in the flotation compartment the watertight riveting and sealing conditions must be met.

The above instructions are applicable to repairs to the nose cover of the stabilizer.

The sketches in Figures 8 and 9 are given to illustrate this type of repair.

Repair of Fuselage Bottom Skin

I. The most important case is the repair of a fuselage damaged in belly landing where bottom rings and corrugations are crushed.

Refer to Fig. 10 for discussion of method of repair.

1. Remove rivets attaching lower corrugations to longerons and remove entire corrugations in damaged area. The extent of the corrugations removed in the fore and aft direction to be governed by the transverse splices.

2. Remove all lower rings that are damaged up to splice. If it is not necessary to remove the entire lower ring the ring should be cut well above the damaged portion and a new ring spliced on. This splice should be made the same as the splice connecting upper and lower sections of original ring.

3. Rivet side skin to new lower ring sections.

Rivet new section of bottom corrugated skin to rings. This skin should be ordered from the Martin Co. as it is difficult to flatter the corrugations at the center line of fuselage and at the longerons. If flattening is tried, it should be done on heat treated corrugated sheet as the corrugated sheet buckles badly during heat treatment.

II. All splices necessary in smooth or corrugated skin must be made with the same lap and the same rivet spacing as used in adjacent splices.

Repair of Fuselage Frame Rings

Should a tube ring be injured, it should, if possible, be straightened and a channel of .040 aluminum alloy sheet fitted closely over the tube and riveted to the skin with 3/32 diameter rivets. Close to each end of the reinforcement, two #8-36 machine screws of aluminum alloy or steel, spaced about 1 inch apart, should be used. These screws should run fore and aft through the tube and reinforcement. Care must be taken not to draw the screws so tight as to compress the tube If a section of the tube must be replaced, a reinforcing splice as noted above, should be placed at the joint between the old and new tubing.

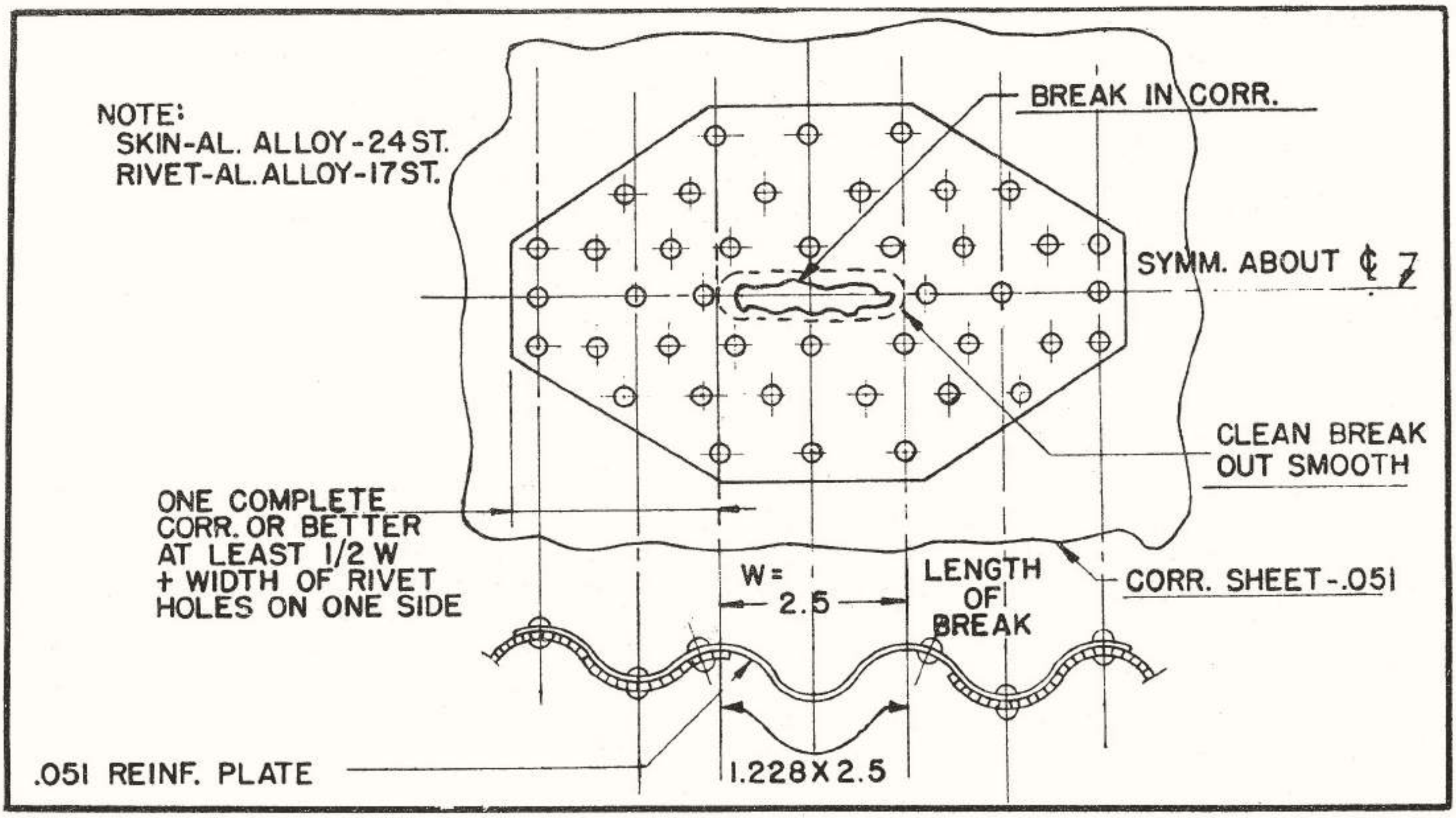


FIGURE 1

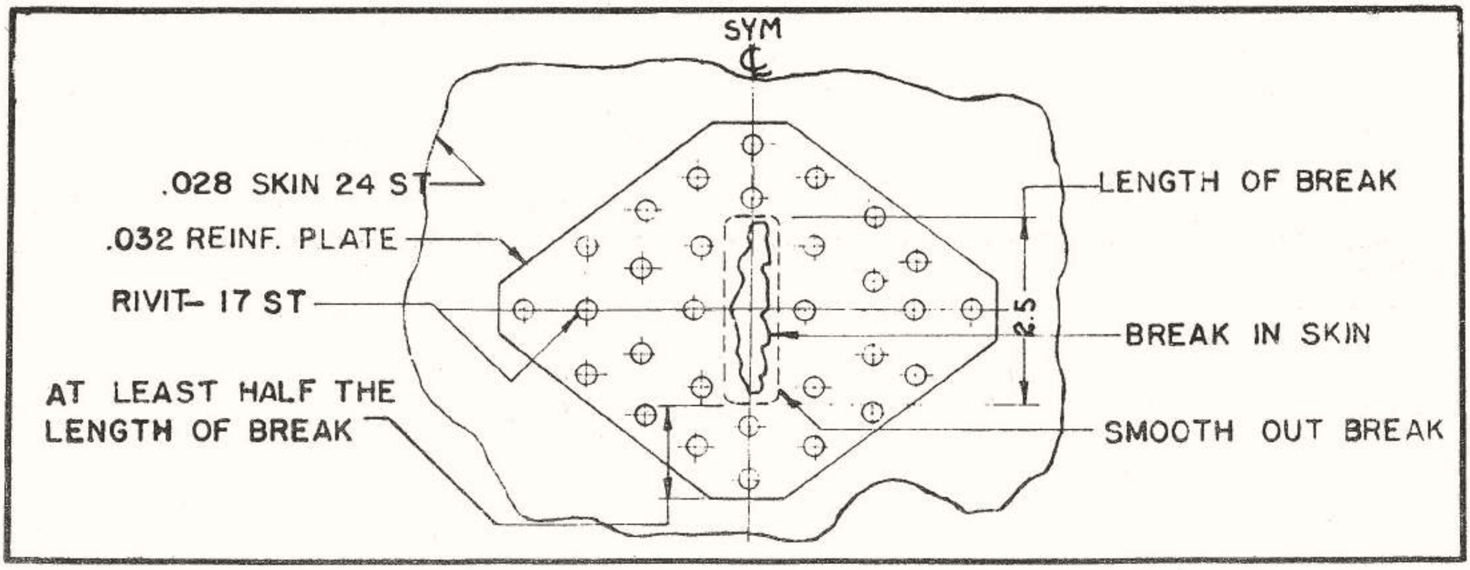


FIGURE 2

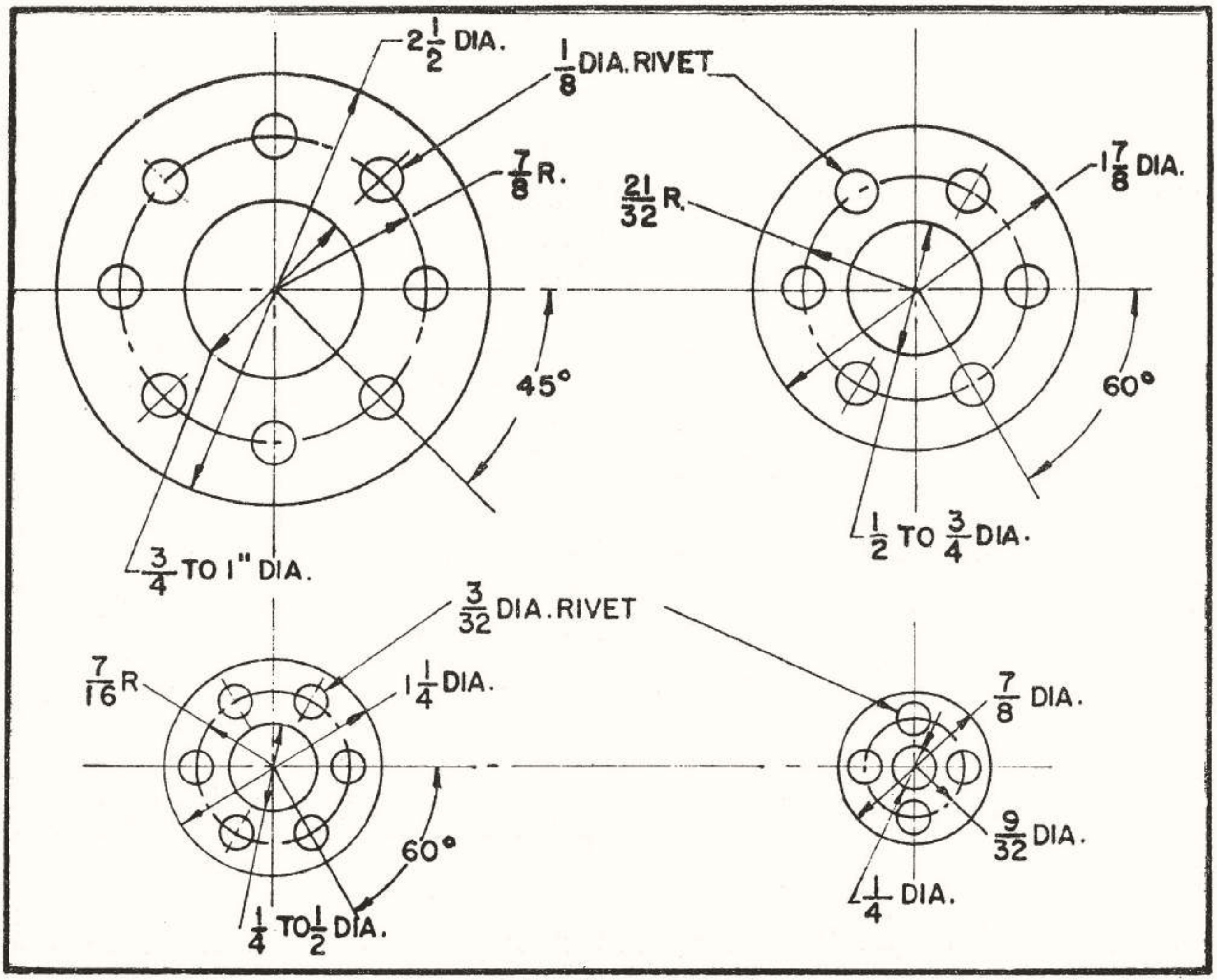
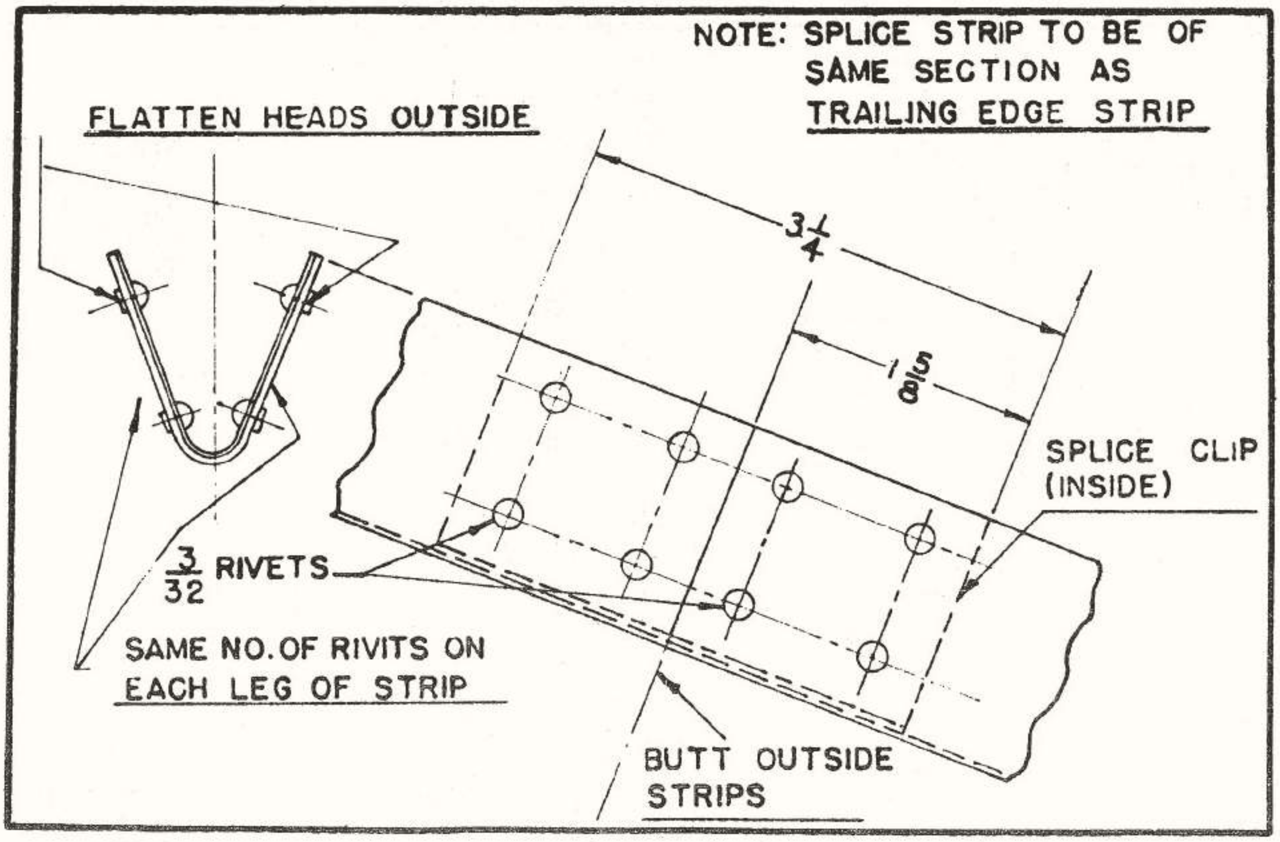


FIGURE 3



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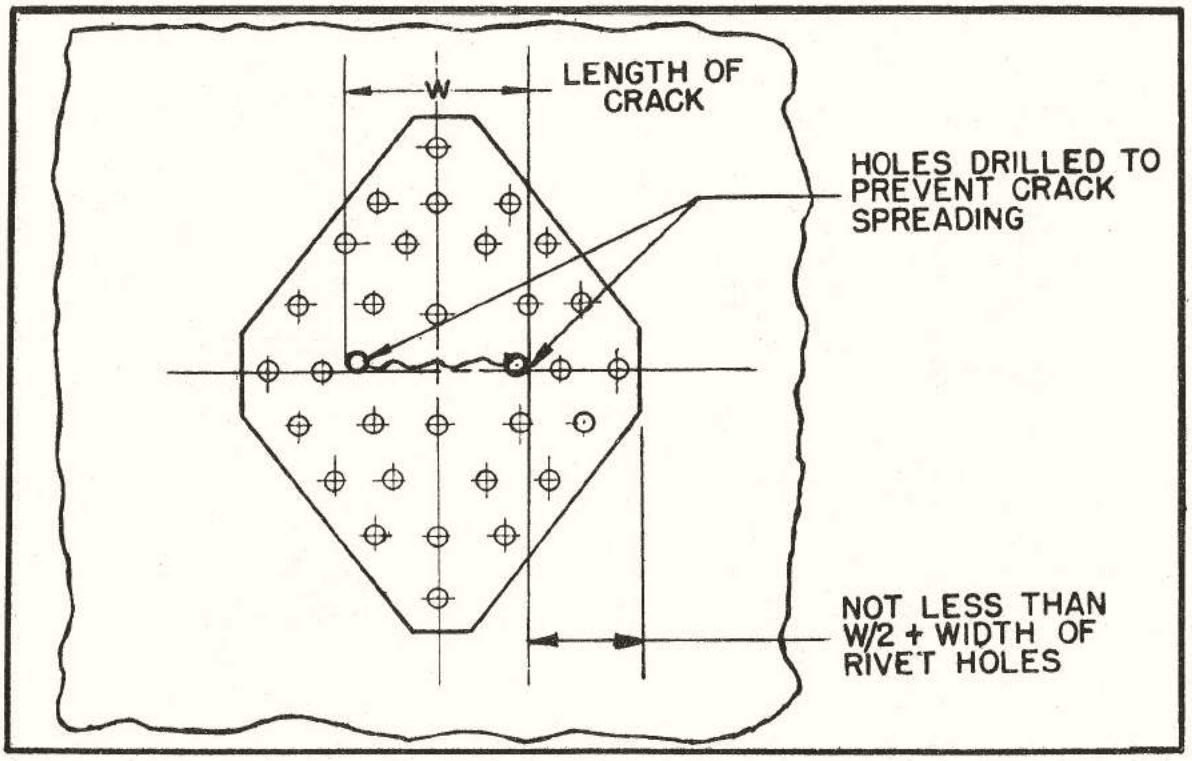
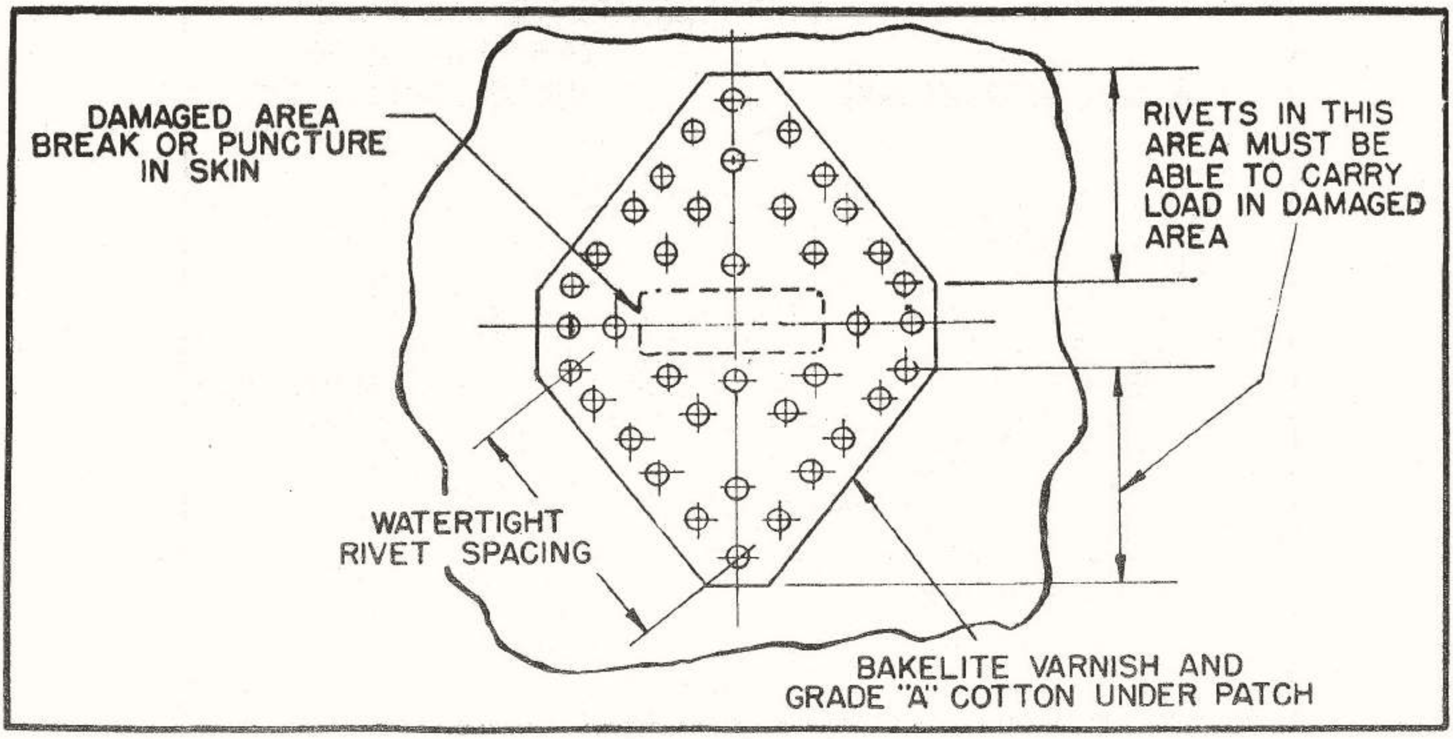


FIGURE 5



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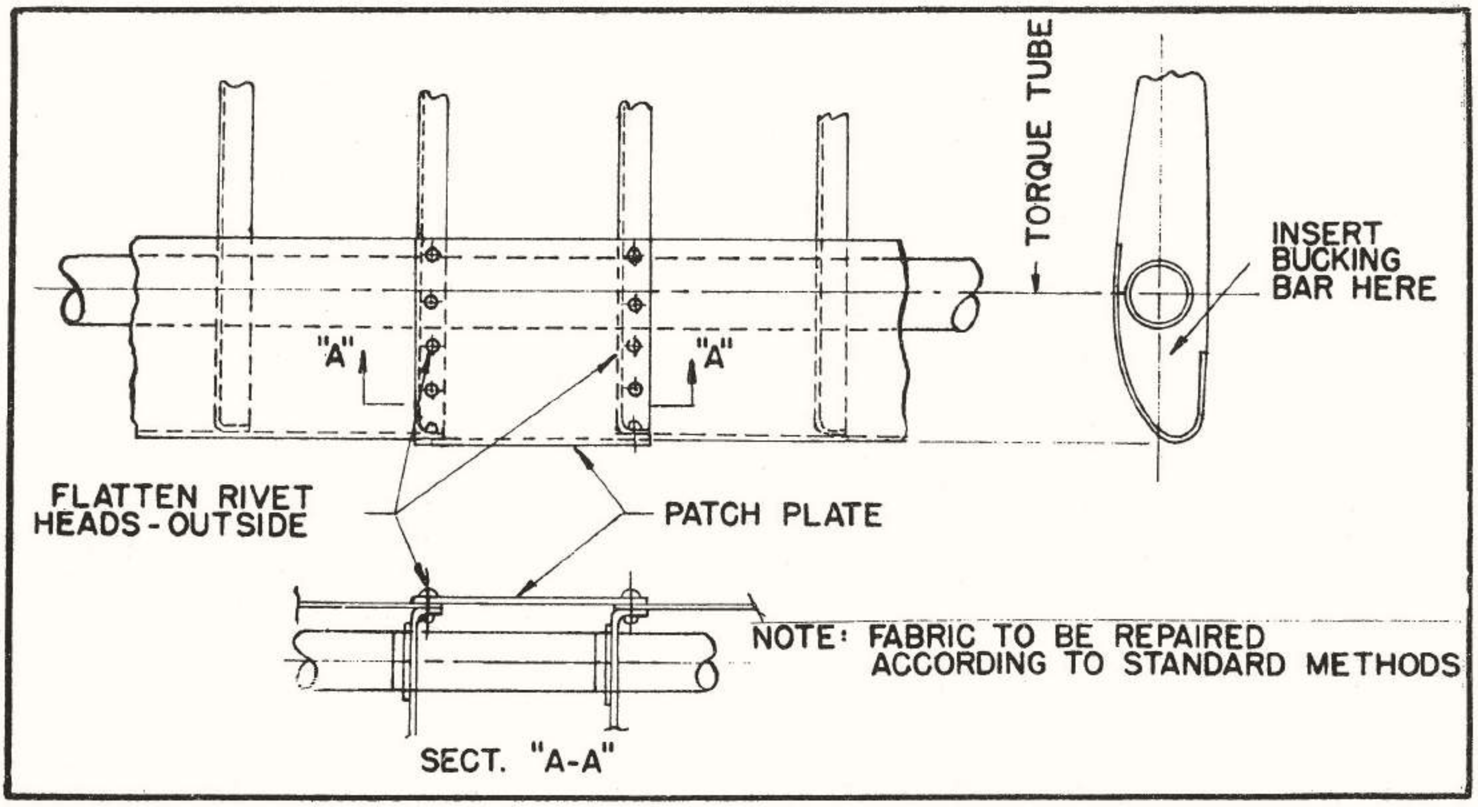


FIGURE 7

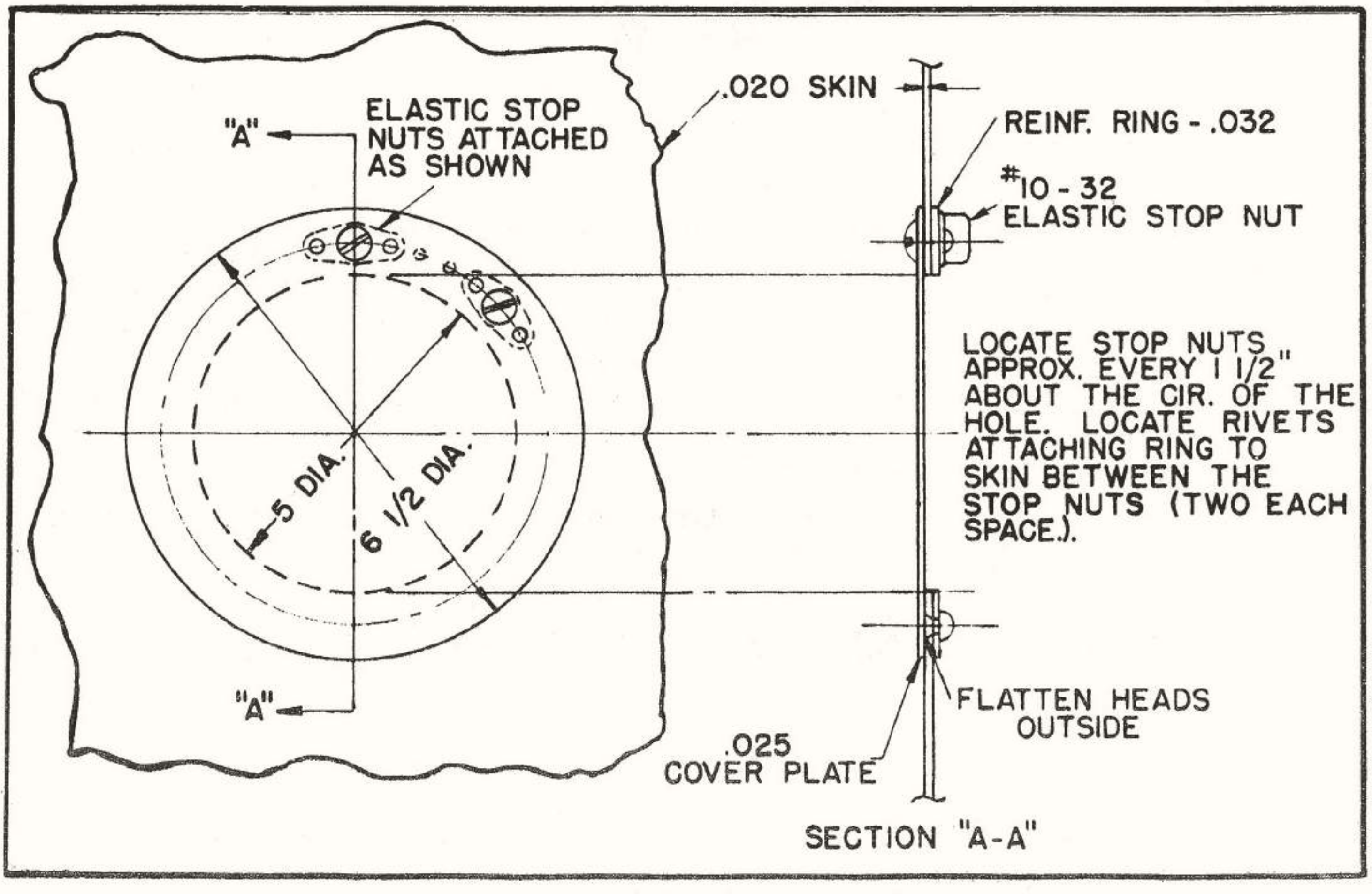


FIGURE 8

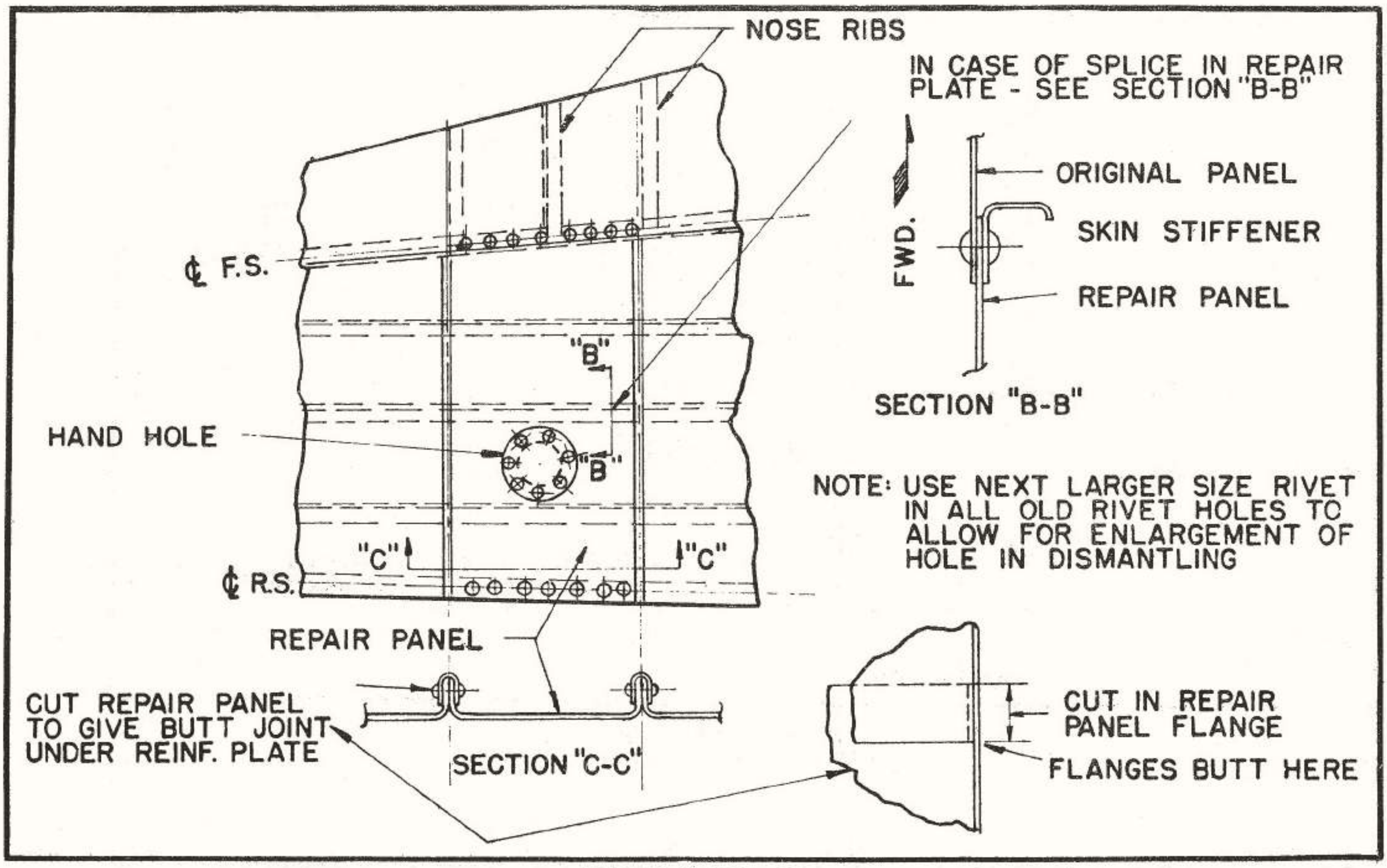


FIGURE 9

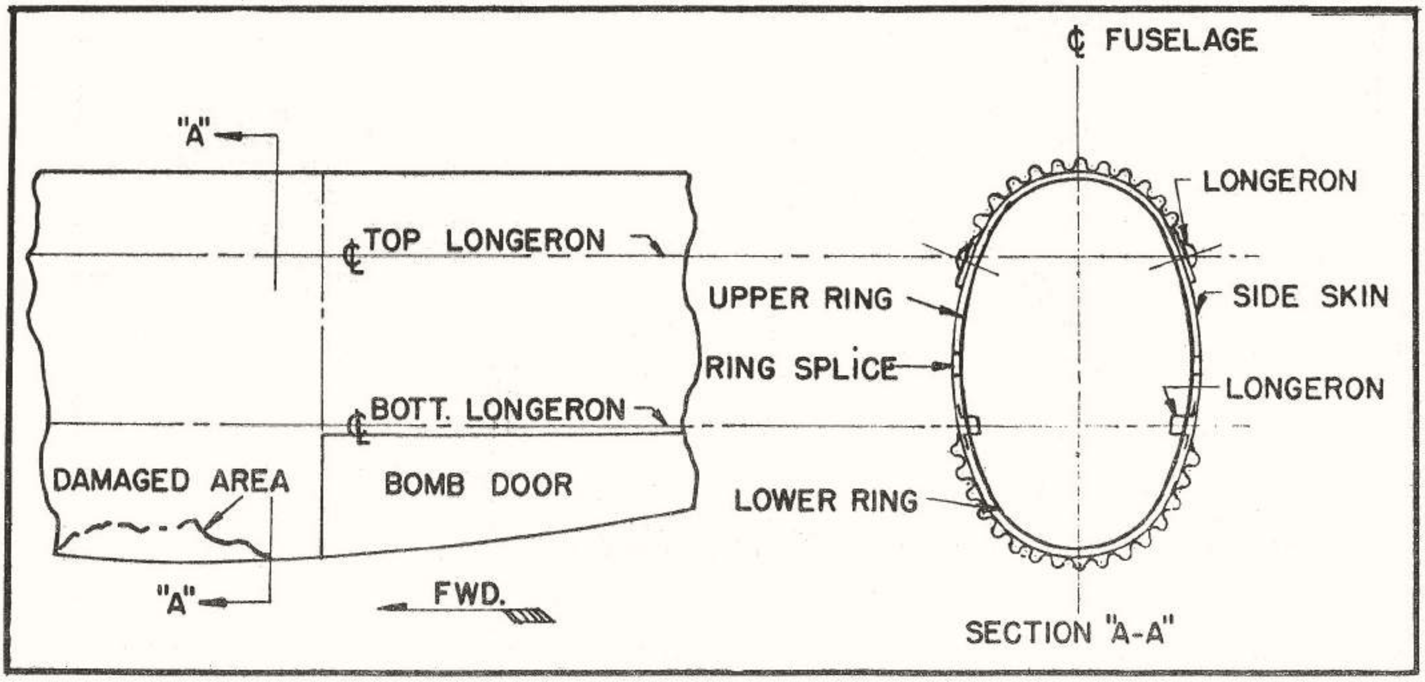


FIGURE 10

APPENDIX I-A

REPAIR OF RIVETED TANKS

The following method of repair of riveted tanks is recommended:

The tanks should be thoroughly drained and the area around the leak should be dried. The exterior of the rivet, or seam which leaks, should be coated with Glyptol Lacquer Primer No. 1201.

If this method fails to stop the leak, the rivets around the area leaking should be tightened by additional driving and the rivets, or seams should be coated with Glyptol Lacquer Primer No. 1201.

If the above methods fail to stop leaking, the following method should be used:

Leaking rivets should be removed and replaced with new rivets, coating the interior of the rivet hole, and the rivet with Bakelite Varnish, and driving while the varnish is sticky or tachy.

Leaking seams may be repaired by removing the rivets along the portion of the seam so affected, and forcing Bakelite Varnish between the seam. The rivets should be replaced in the same manner as above. Wherever possible, it is also desirable to coat the interior of the tank along the leaking seam with Bakelite Varnish.

See Appendix IV for compounds.

APPENDIX II

Miscellaneous Instruction Data for Airplane Accessories

The following list of Manufacturers' handbooks pamphlets, bulletins, drawings, etc., are included with each Maintenance Manual.

A. WRIGHT CYCLONE ENGINE Instruction Book R-1820-G and GR-1820-G Series dated October, 1937.

B. BENDIX SCINTILLA AIRCRAFT MAGNETOS
Parts Price List and Service Instructions Type SF9L-1 Magnetos dated November, 1937.

C. CURTISS PROPELLER Installation and Maintenance Instructions, Curtiss Feathering Propellers. Dated July 15, 1938 also includes:

C(1) Parts List, Model C-532-D, Assembly Drawing No. 55003-E-2 Installed in Martin WH-3 Airplanes dated July 18, 1938.

D. SPERRY INSTRUCTIONS No. 15-726C for the Operation and Installation of the Sperry Gyropilot dated February, 1938.

E. CAMBRIDGE INSTRUMENT COMPANY
Instructions for the Use and Care of Two Engine Aero Mixture Indicator S.O. 54244 Serial No. Type D.I.R.

A separate cover titled "Miscellaneous Bulletins for Aircraft Instruments" which accompanies each Maintenance Manual contains the following data in the order shown.

THE ELECTRIC STORAGE BATTERY CO.

1. Instructions Installing and Operating Exide Batteries in Aircraft Service Form 2754 Tenth Edition dated February, 1937.

ECLIPSE AVIATION CORPORATION

1. Instruction Book No. 32 for Type Y-150 Landing Gear Motor, also:-
2. Supplement No. 1 Service Parts List
3. Instruction Book No. 37 for Type Series 11 Aviation Engine Starters Inertia Type, also:-
4. Supplement No. 3 Series 11 and Series 11-A Inertia Starters and Booster Magnetos
5. Supplement No. 4 Accelerating Motors for Inertia Starters
6. Instruction Book No. 1-B Single Voltage-Engine Driven Aircraft Generator with Three Unit Control Box Separately Mounted, also:-
7. Supplement No. 3 Type E, Single Voltage Generators
8. Instruction Book No. 38 Supercharger Regulator for Wright Cyclone Engine includes:-
9. Supplement to Instruction Book No. 38, Installation Drawing and Service Parts List Eclipse Model 3217A-2 Supercharger Regulator dated June 1, 1938.

THE LEECE-NEVILLE COMPANY

Instructions, Type A-1 Generator Voltage Regulator Control Unit, dated June 2, 1938.

WRIGHT AERONAUTICAL CORPORATION

1. Bulletin No. 5815A Lubricating Oils
2. Bulletin No. 5817A Lubricating Oils for High Output Engines
3. Instructions for the Operation and Maintenance of the Wright Cyclone Two-Speed Supercharger. Supplement Part No. 67307, dated May, 1938
4. Specification No. 286-Q for R and GR-1820-G5 (Cyclone Engines)

STROMBERG CARBURETOR CORP.

1. Instructions on Stromberg NA-F7C, NA-F7E, and NA-F7F Carburetors Form 10-150-2500-1-37-SPI with:-
2. Instructions for NA-F7F2 Carburetors with Stromberg Drawing No. A-18037

THE PUMP ENGINEERING SERVICE CORPORATION

1. Service Manual for Pesco Fuel Pump Model R-600-B A.C. Type C-7, dated August, 1937
2. Instruction Manual for Pesco Vacuum Pump Model 202 Type B-1A, dated August, 1936
3. Handbook of Instructions for Pesco High Pressure Oil Pump
4. Handbook of Instructions for Pesco Fuel Valves Models 239-240, and 241, dated June, 1938

SPERRY GYROSCOPE COMPANY

1. Drawing No. 642784-F Oil Pressure Regulator (Pulsation Damped) Gyropilot
2. Drawing No. 642878-E Oil Filter Unit Gyropilot
3. Drawing No. 75688-F Equipment Outline Martin 139 Gyropilot

BENDIX PRODUCTS CORPORATION

Technical Note, Bendix Cast Streamline Airplane Wheels and Brakes, dated October, 1935

WARNER AIRCRAFT CORPORATION

1. Instructions for Brake Control Unit, List 1016 (6 pages)
2. Drawing SK2298-A Control Unit-Hydraulic Brake Service Instructions
3. Drawing SK-2310 Control Unit Operation Diagram (2 pages)
4. Drawing 3150-1 Control Unit-Hydraulic Brake

CLEVELAND PNEUMATIC TOOL COMPANY

Aerol Strut Maintenance and Service Instructions for:

1. Tail Wheel Oleo Strut, Type B-137-M, Bulletin No. 2
2. Wing Flap Control Cylinder, Type WFC, Bulletin No. 3
3. Hydraulic Wing Flap Pump, Type WFP, Bulletin No. 4
4. Main Leg Oleo Strut, Type 7562, Bulletin No. 5

SOLAR AIRCRAFT COMPANY

Standard Repair Instructions for Exhaust Manifolds (2 pages), dated December 15, 1937

UNITED AIRCRAFT PRODUCTS, INC.

1. Maintenance Instructions for Oil Temperature Regulators, dated February 1, 1938
2. Drawing No. U-3250-D-1 Valve Assembly-Oil Bypass and Relief, Type D-1
3. Drawing No. U-3210 Oil Temperature Regulator
4. Instructions, Type D-3 (AN-4014) Hand Re-fueling Pump, dated February 1, 1938
5. Drawing No. U-300-A Assembly, Hand Refueling Pump-Type D-3
6. Drawing No. U-2351 Type D-6 Fuel Unit Assembly

THE LIQUIDOMETER CORPORATION

Installation and Service Liquidometer Aircraft Type Fuel and Oil Quantity Electric Gauges Type 101

AIR CRUISERS, INCORPORATED

Instructions for the Care and Operation of the "Inflatex" Rubber Boat

INTERNATIONAL FLARE-SIGNAL

Instruction Sheet for Using Pistol Operated Types

WILEY FLARE

Instruction Sheet for the Type A-8 Wiley Parachute Flare

PYRENE MANUFACTURING COMPANY

Important Information for Users of 1 Pint, 1 Quart, and 1½ Quarts Pyrene Fire Extinguishers Form No. 116-10-37.

ECLIPSE AVIATION CORPORATION

Overhaul Manual Section, Routine Installation, and Service Instructions Engine Synchroscopes File OM-S

KOLLSMAN INSTRUMENT COMPANY

1. Aviation Clock (8 day)	Type 133-01
2. Air Speed Indicator	Type 157-03
3. Compass	Type 58L
4. Engine Thermometer	Type 30-04
5. Manifold Pressure Gauge	Type 162-03
6. Pressure Gauges & Suction Gauges	
Fuel Pressure Gauge	Type 130-03
Oil Pressure Gauge	Type 131-05
7. Pitot Static Tubes, Electrically Heated	Type 171-E
8. Sensitive Altimeter	Type 134 Series
9. Vertical Speed Indicator	Type 164 Series

PIONEER INSTRUMENT COMPANY

1. Fuel Pressure Warning Unit	Type 1173
2. Turn and Bank Indicator	Type 385-E

WESTON ELECTRICAL INSTRUMENT CORP.

Installation and Service Instructions for:

1. Weston Indicators, Model 545 No. 215 Sub 5
2. Weston Thermocouple Type Thermometers, Model 602, No. D-215, Sub 6
3. Weston Resistance Type Thermometers, Model 606, No. D-215, Sub 8
4. Weston Tachometer Magnetos, Model 724 Types B and C, No. D-215, Sub 9

APPENDIX III

The following is a list of important drawings furnished with this Manual:

R-184000	General Assembly
C-124046	Installation-Tail Wheel
R-124047	Installation-Landing Gear
R-184061	Installation-Oil System
R-124113	Installation-Brake System
R-165055	Installation-Engine Controls
R-184127	Installation-Radio
*R-165128	Installation-Wiring Diagram-Radio
R-184052	Installation-Engine
R-184056	Installation-Fuel System
R-141112	Installation-Surface Controls
R-168065	Installation-Cowl-Engine
*R-184117	Diagram-Electrical Wiring
R-184114	Installation-Fuselage Electrical Equipment
R-141116	Installation-Nacelle Electrical Equipment
D-184304	Installation-Cowl Flap Controls
D-184779	Crank Assembly & Cable Connect.-Cowl Flap Controls
P-184170	Installation-Bomb Release (Electrical)
*D-184169	Diagram-Wiring, Simplified (Internal Bomb Rack)
*P-184118	Diagram-Wiring, Simplified (Airplane)
C-165625	Installation-Exhaust Analyzer Engine Installation
B-163151	Installation-Cambridge Exhaust Analyzer
D-165270	Installation-Curtiss Propeller Pitch Control
D-165175	Installation-Curtiss Propeller Control (Electrical)
*D-141194	Diagram-Electrical Operation of Landing Gear
R-184041	Frame Assembly, Fuselage (Splice)
R-164270	Installation-Automatic Pilot
D-185290	Installation-Automatic Pilot-Nacelle Furnishings
P-141776	Installation-Cables Follow-Up-Automatic Pilot-Fuselage
D-138524	Installation-Valve Control Servo Unit-Surface Controls
R-184121	Installation-Aeronautical Instruments
R-184104	Installation-External Bomb Rack Controls
R-184105	Installation-Bomb Releases Internal
D-185090	Installation-Forward Oxygen Equipment
D-137417	Installation Oxygen Equipment-Rear Furnishings

*Drawing also supplied in diagram pocket of airplane.

A

APPENDIX IV
Lubricants and Compounds

USE	COMPOUND	U.S.GOV'T SPEC.	COMMERCIAL EQUIVALENT	MANUFACTURER
For heavy duty sealed gears and bearings.	Transmission Oil (Heavy)	AC 2-98	"Penola" Compound #4.	Standard Oil Co. of New Jersey Main Office is at 26 Broadway, New York, N.Y.
Zerk fittings, flaps, landing gear, bomb door, etc. Bomb Door retracting screw tab indicating screw threads.	Cup Grease, External Use; and Thread Lubricant for certain bolt threads	Fed. VV-G-681 Formerly AC-2-29-D	"Castroleum" (3 grades according to climate.	Standard Oil Co. of New Jersey
Control System ball bearings, (sealed and open).	Light grease low freezing point	AC 3584	"Parmo" Petrolatum	Standard Oil Co. of New Jersey
Landing wheel bearings	Heavy grease (fibrous)	AC 3560C Grade 295	"Penola" Anti-Friction A.	Standard Oil Co. of New Jersey
Landing Gear strut bearings; starter crank	Graphite Grease	Fed. VV-G-671 (Soft)	"Van Estan" #3	Standard Oil Co. of New Jersey
Bomb rack tripping fingers	Under-water gear grease	--------	Esso Marine Grease ("U.G.")	Standard Oil Co. of New Jersey
Propeller counter-weights (Ham.St'd)	Light lubricating grease	AC 299	"Castroleum" (Grade 1 only)	Standard Oil Co. of New Jersey
Curtiss and Hamilton St'd propellers	Propeller blade bearing grease	AC 3581 (Medium)	"Mobil-grease" #2	Socony Vacuum, Inc., 26 Broadway, New York, N.Y.
(Curtiss Propellers only)	Propeller Speed Reducer Gearbox Lub.	AC Y-3587	Speed Reducer Oil #1(Curtiss)	Socony-Vacuum Inc., 26 Broadway, New York, N.Y.
Cables, king pins, and bolts; Dzus Fasteners	Rust Preventive (External use)	AC 2-82-B	"Corol" ordnance machine grease	Simoniz Co., Chicago, Illinois
Spray in engine cylinders Spray engine externally for storage	Rust Preventive (Internal use)	AC 3568-A	Ethyl Gasoline Anti-Ruse Compound "E.G.-174."	Park Chemical Co., Detroit, Mich.
Pipe threads; aluminum alloy threads	Thread Lubricant (ordinary)	AC 3571-A	Parker "Threadlube", No. 6PE	Parker Appliance Co., Cleveland, Ohio.
Pipe thread anti-seize	Thread Lubricant (threads subjected to heat)	--------	"Anograph"	The Glenn L. Martin Co., Baltimore, Md.

Appendix IV continued

USE	COMPOUND	U.S.GOV'T SPEC.	COMMERCIAL EQUIVALENT	MANUFACTURER
Generator and Starter Motor ball bearings; Magneto gears and bearings	Special high temperature grease	---------	"Bosch" 501	United American Bosch Corp., Springfield, Mass.
Inertia Starter bearings (ball and roller)	Special grease	AC 3560-C (Soft)	"Tulc"-VH	Universal Lubricant Co., Cleveland, Ohio.
Gears, plain bearings, and clutch discs of Inertia Starters	Special graphite grease	(Int.) Grade"AA"	"Gredag" #32	Acheson Graphite Co., Niagara Falls, N.Y.
Generator clutch plates and counterweight plate assembly; Magneto cam follower felt	Machine oil	Fed. VV-0-496 S.A.E.#20	S.A.E. #20	(Various)
Condition leather oil seals by immersion in this oil at 100°F.	Leather-treating oil	AC 2-66	"Neatsfoot" Oil	Seidler Chemical & Supply Co., 16 Orange St., Newark, N.J.
Rusted and seized nuts, threads, joints, etc.	Penetrating Oil		"Marvel Mystery Oil"	Emerol Mfg. Co., 242 W. 69th St., New York, N. Y.
Magento distributor gears	Special grease	(Soft)	"Keystone" #44	Keystone Grease Corp., Philadelphia, Pa.
Moveable parts of carburetor	Gasoline resistant grease	---------	(Castor Oil Graphite.)	(Mix locally)
Dry Lubricant (general use)	Graphite	(Small)	(Flake Graphite, fine)	Acheson Graphite Co., Niagara Falls, N.Y.
Welding Corrosion and heat resisting steel (manifold repairs, etc.)	Flux		"Oxweld Crom Aloy"	Linde Air Products Co., 30 E. 42nd St., New York, N.Y.
Mix with butyl alcohol for shock absorber oleos; also brake system.	Castor Oil	AC 2-8-B	Castor Oil Grade AA	Baker Castor Oil Co., 120 Broadway, New York, N.Y.

USE	COMPOUND	U.S. GOV'T SPEC.	COMMERCIAL EQUIVALENT	MANUFACTURER
Oleo Fluid . (mixed with Castor Oil- See Castor Oil.) Also for Brakes	Butyl Alcohol	AC-4-1071	Butyl Alcohol	U.S. Industrial Alcohol Co. 60 E. 42nd St., New York, N.Y.
		AC-14094	Diacetone Alcohol	
Gyro-Pilot-(Sperry) Flap Cylinders	Automatic Pilot Oil		Sperry "S.S." Oil;Spec. P-69555 or Mobiloil "S.S."	Sperry Gyroscope Co., Brooklyn, N.Y. Socony Vacuum, Inc., 26 Broadway New York, N.Y.
Spark Plug Threads	Spark Plug Lubricant	AC-3578	(Special)	B-G Corp., 136 W. 42nd St., New York, N.Y.
Cleaning "Plastacelle" and celluloid	Cleaner	AC-20014	"Cel-U-Clear"	Nicholas-Beazley Airplane Supply Co., Floyd Bennet Field, Brooklyn, N.Y.
Engine fuel (All Cyclone "F-50" and "G" Series)	Gasoline (See Wright Spec. 5803)	AC-2-95	Aviation gasoline, commercial octane rating 8.7 (C.F.R.)	(Various)
Cleaning Bomb Racks	Kerosene	Fed. VV-K-211	Kerosene	(Various)
Repair Fuel-Oil Tank Seams	Bakelite Varnish		Pratt and Lambert #2108	Pratt and Lambert, Buffalo, N.Y.
Repair Fuel-Oil Tank Seams	Glyptol Lacquer Primer	-------	General Electric Co., No. 1201	General Electric Co., Schenectady, N.Y.
Polishing Reflectors	Silver Polish	Fed. P-P-571A, Type "A" or "B"	Wright Silver Polish	J.H. Wright & Co., Keene, New Hampshire, U.S.A.
Thinner Rubber Cement	Benzol	2-58-B	Benzol	Standard Oil Co. of New Jersey, 26 Broadway, New York, N.Y.
Attaching Rubber Walkways to Rubber & Metal	Liquid Rub. Cement	-------	"Plastikon"	B.F. Goodrich Co., Akron, Ohio
	Liquid Rubber Sealing Cement	-------	Neoprene Cement Type I	E.I. duPont de Nemours & Co., Philadelphia, Pennsylvania
Seal Metal Radio Mast to Plasticele	Plastic Rubber Cement	-------	Bostik Universal Cement No. 292	B.B. Chemical Co., Cambridge, Massachusetts
Attaching Abrasion Shoes to Stabilizers	Liquid Rubber Cement	-------	Vulcalock Cement No. 1	B.F. Goodrich Co., Akron, Ohio

USE	COMPOUND	U.S. GOV'T SPEC.	COMMERCIAL EQUIVALENT	MANUFACTURER
Oil-Forced-Feed Lubrication for Engines (Cyclone "G" series); for universals, plain bearings, open friction joints, and bearings. (See Wright Specification 5817-A.)		AC-2-91	"Elektrion" 5050	DeGavel & Roegiers, European Refiners
			"Aero Heavy X"	Dutch Shell, European Refiners
			"Wolf's-Head" 130 H.O.	Wolverine-Empire Refining Co., 51 Madison Ave., New York, N.Y.
			"Texaco"120-WAC-F	The Texas Co., 125 E. 42nd St., New York, N.Y.
			Gulf Oil #60 Airfleet	Gulf Refining Co., 3800 Gulf Bldg., Pittsburgh, Pa.
			"Stanavo" D-37	Standard Oil Co. of New Jersey 26 Broadway, New York, N.Y.
			Esso Aviation Oil 120-G	Standard Oil Co. of New Jersey 26 Broadway, New York, N.Y.
			"Socony" IAA71 INTAVA "Green Band"-Foreign	Socony Vacuum Co., 26 Broadway, New York, N.Y.
			"Sinclair-Penn" 120G	Sinclair Refining Company, 630-5th Ave., New York, N.Y.

Note: In the foregoing list the U.S. Government Specification shown in some instances may not be identical with the Commercial Equivalent, but will be that which applies most closely.

CLASSIFIED FITS FOR *"AN" BOLTS (INCHES)

Bolt	AN Bolts-Limits, Dia. of New Bolt	Nominal Hole Size	Fit 1 (St'd. Ream)	Fit 2 (Ream)	*Fit 3 (St'd. Drill)	Fit 4 (Drill)
AN3 (3/16)	+.0000 .189 -.0025	.190	#10-32 Bolt Not Used in Primary Structure		+.005 .189 -.000	+.005 .193 -.000
AN4 (1/4)	+.000 .249 -.003	.250	.250 ±.001	.250 ±.002	+.006 .250 -.000	+.006 .257 -.000
AN5 (5/16)	+.000 .3115 -.003	.3125	.3125±.001	.3125±.002	+.006 .3125 -.000	+.006 .316 -.000
AN6 (3/8)	+.000 .374 -.003	.375	.375 ±.001	.375 ±.002	+.008 .375 -.000	+.008 .377 -.000
AN7 (7/16)	+.0000 .4365 -.0035	.4375	.4375±.001	.4375±.002	+.008 .4375 -.000	+.008 .4531 -.000
AN8 (1/2)	+.0000 .499 -.0035	.500	.500 ±.001	.500 ±.002	+.008 .500 -.000	+.008 .5156 -.000
AN9 (9/16)	+.000 .5615 -.004	.5625	.5625±.001	+.002 .5625 -.001	+.008 .5625 -.000	*For Phenol Fiber, drill hole 1/64 larger than bolt.
AN10 (5/8)	+.000 .624 -.004	.625	.625 ±.001	+.002 .625 -.001	+.010 .625 -.000	
AN12 (3/4)	+.0000 .749 -.0045	.750	.750 +.001	+.002 .750 -.001	+.010 .750 -.000	

Fit 1: Use where 1 or 2 bolts are used as hinge or connecting pins in primary structure such as fuselage, wings, mounts, struts, controls, which are subjected to reversible loads or vibration.

Fit 2: Use where a number of bolts are used in primary structure to attach fitting to structure subjected to reversible loads or vibration and where a rigid joint connection is essential.

Fit 3: Use where bolts are used to attach brackets, clips, accessories, or where a quantity of bolts are used to attach sheet or plate material such as cover plates, tension field splice connections, etc.

Fit 4: Use where a loose fit is desired on bolts attaching certain brackets, fittings, or accessories in order to fit interchangeably, or on installations where jigged holes are not necessary.

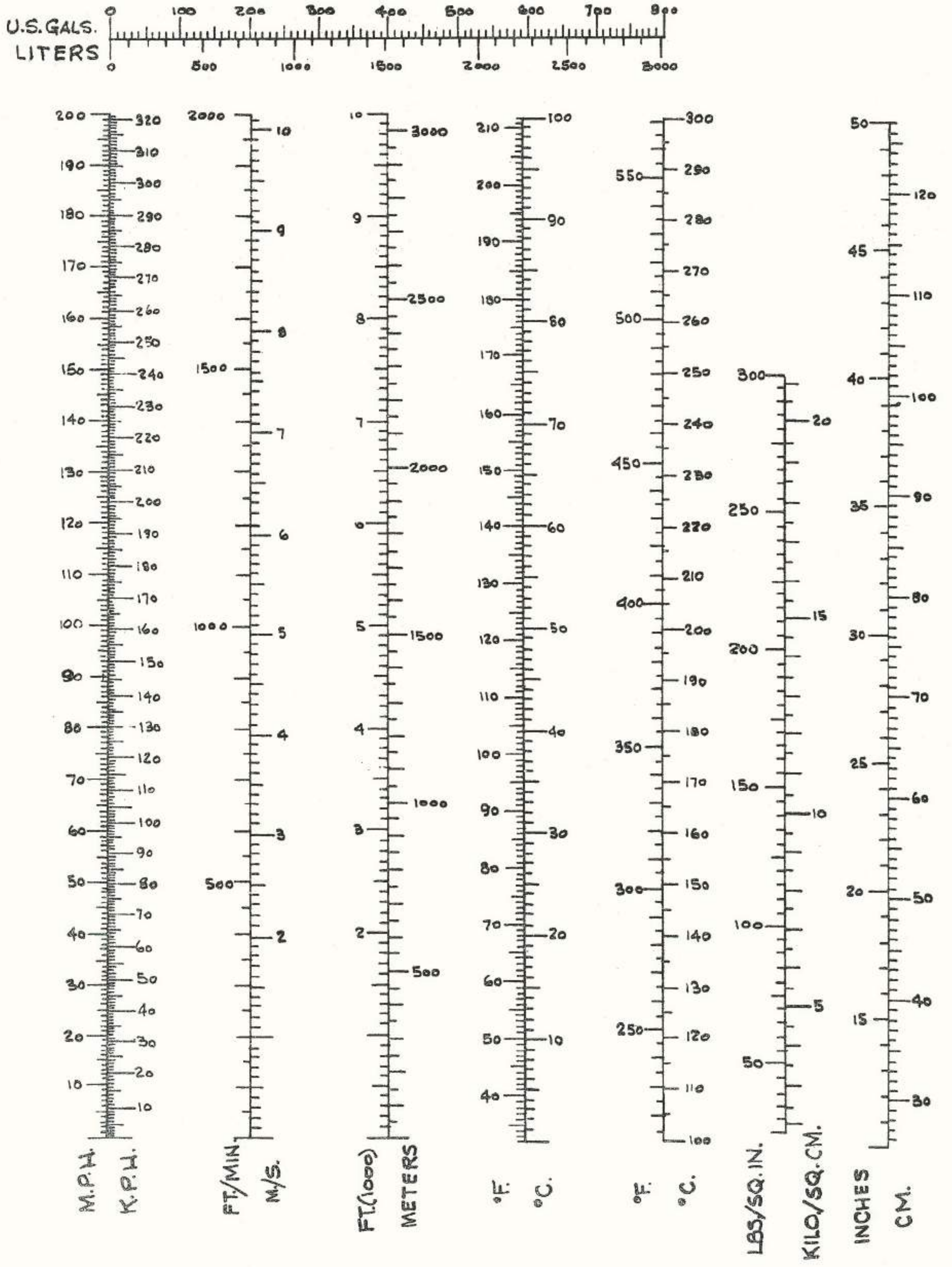
*"AN" means Army and Navy Standards.

STEEL BUSHING TOLERANCES (Inches)

Bolt Size	Inside dia. of Bushing	Ream Size (press fit on O. D.)	O.D. of Bushing	Tolerance (Short Bushing)	Tolerance (Long Bushing --over $1\frac{1}{2}$" long)
#10	.190 ±.001	.3125 +.001 -.0005	.3145	±.0005	+.0000 -.0005
1/4	.250 ±.001	.375 +.001 -.0005	.377	±.0005	+.0000 -.0005
5/16	.3125±.001	.4375 +.001 -.0005	.4395	±.0005	+.0000 -.0005
3/8	.375 ±.001	.500 +.001 -.0005	.502	±.0005	+.0000 -.0005
7/16	.4375±.001	.5625 +.001 -.0005	.5645	±.0005	+.0000 -.0005
1/2	.500 ±.001	.625 +.001 -.0005	.627	±.0005	+.0000 -.0005

TAP DRILL SIZES (FOR FINE THREADS)

Tap Size	Tap Drill Size
#10-32	#23 (.154)
1/4-28	# 3 (.213)
5/16-24	I (.272)
3/8-24	Q (.332)
7/16-20	25/64 (.3906)
1/2-20	29/64 (.4531)
9/16-18	33/64 (.5156)
5/8-18	37/64 (.5781)
3/4-16	11/16 (.6875)
7/8-14	13/16 (.8125)
1-14	15/16 (.9375)



ENGLISH - METRIC CONVERSION SCALES