VULTEE AIRCRAFT, INC.

ENGINEERING AND DEVELOPMENT DEPT.

REPORT NO. 260-28

ANALYSIS OF THE MESSERSCHMITT ME-110 AIRPLANE

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INTRODUCTION

We were fortunate in obtaining a complete Messerschmitt Me110-C multi-place fighter for the purpose of engineering investigation and analysis. The airplane was received in exceptionally fine condition, with practically every piece of equipment in working order, which enabled us to conduct detailed studies and tests of the more interesting equipment and structure.

We have completed a lengthy investigation of this airplane, and herein present an analysis of our findings, in the hope that others in the aircraft and related industries may find the information of interest and value.

R. W. Palmer
Vice President in Charge
of Engineering
Vultee Aircraft, Inc.

Vultee Field, Calif.
December, 1941

LEADING PARTICULARS

LEADING PARTICULARS

General

Type	Three-seater, twin-engined, low wing, land monoplane
Duty	Long Range Fighter
Overall span	53 ft. 5 in
Overall length	40 ft. 6 in.
Overall height	10 ft. 9 in.
Fuselage maximum width	35 in.

Wing

Total area	414 sq. ft.
Mean aerodynamic chord	92 in
Taper ratio	2.7:1
Aspect Ratio	7.3:1 (approx.)
Main spar location	38.75% of chord
Dihedral	5-1/2 deg.
Wing loading	37 lbs/sq.ft. (approx.)
Wing weight	4.8 lbs/sq.ft. (approx.)

Landing Gear

Tread	15 ft. 2 in.
Tires - Main Gear	875 x 320 (metric)
Tail Gear	465 x 165 (metric)
Brakes	Dual, 1-3/4 x 10-3/4

Engine

Name	Daimler-Benz DB601

Engine, (Continued)

Type	12-cylinder, poppet valve, liquid cooled, inverted Vee--supercharged, spark-ignition and fuel injection.
Fuel	87 octane min.

Propellers

Name	VDM
Type	Three-blade, controllable pitch, full feathering.
Diameter	11 ft.
Control	Electric motor

Armament

Fixed guns	Four 8 mm. (approx. cal. .32)--nose mounted.
Cannon	Two 20 mm.--nose mounted
Flexible guns	One 8 mm., Ring and bead sight.
Bombs (alternate load)	Two 250 kg.

Tank Capacities

Fuel	
Normal -- 4 tanks	340 gal.
Maximum -- 6 tanks	480 gal.
Oil	
Two tanks	11.5 gal. each
Fuel to oil ratio	14:8 nor., 21:1 max.

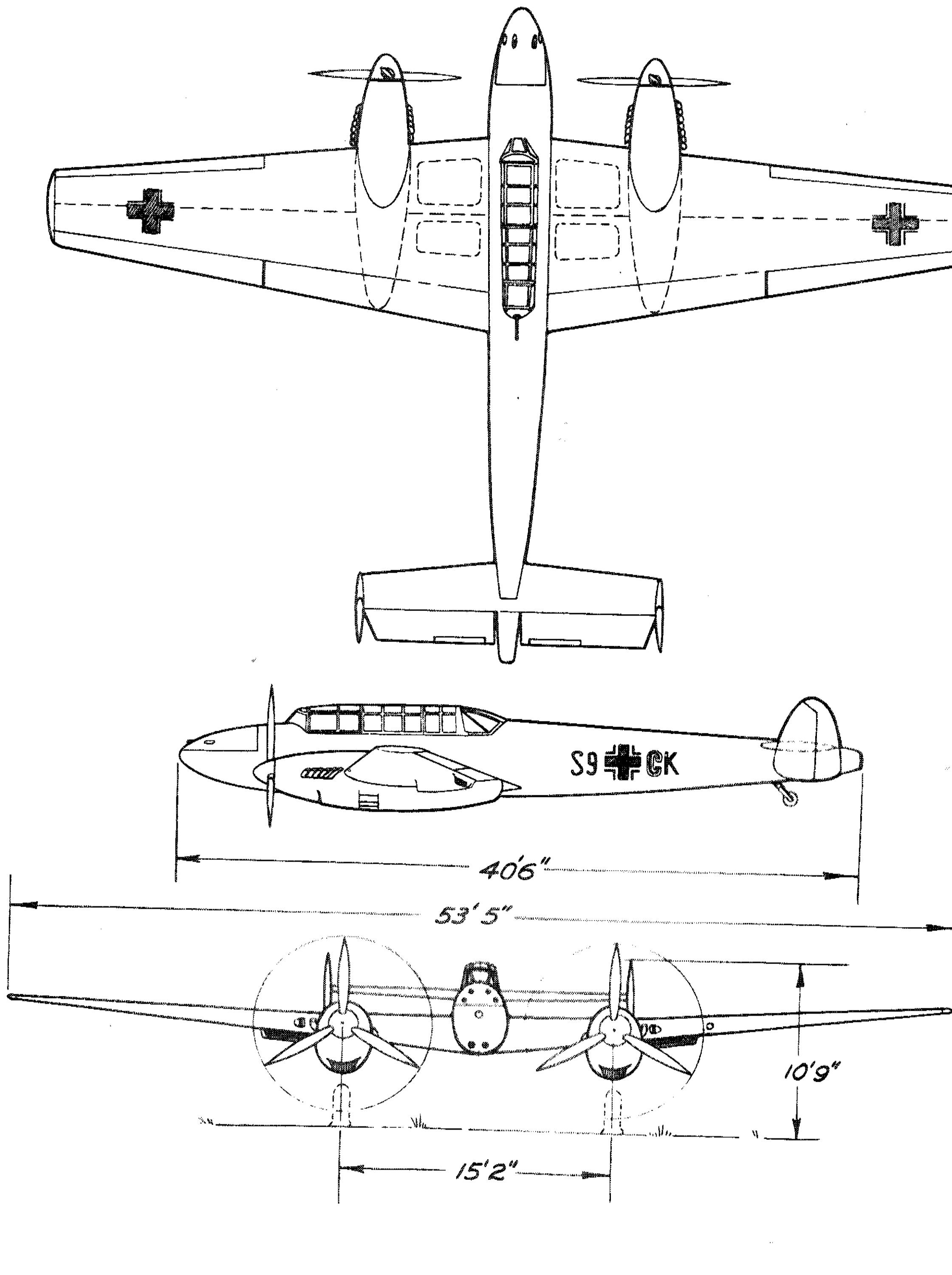
Weights (approximate)

Weight empty	9,900 lb.
Useful load	5,400 lb.
Gross weight	15,300 lb.

Performance

Maximum speed at 19,000 ft. ------------------------	365 mph
Maximum cruising speed at sea level ---------------	263 mph
Maximum cruising speed at 16,404 ft. --------------	304 mph
Maximum cruising speed at 22,966 ft. --------------	301 mph
Range at cruising power and speed -----------------	565 miles
Maximum range at most economical power ------------	1,750 miles (estimated)
Maximum duration ----------------------------------	7.0 hours (estimated)

Leading Particulars



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Chapter 1

GENERAL

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SECTION I

Chapter 1

GENERAL

The Messerschmitt Me110 long-range fighter is an airplane designed for "blitzkrieg production" as well as blitzkrieg warfare. A brief examination will reveal that its designers gave careful attention to the basic factors governing mass production practicability and economy -- design simplifaction; elimination of close limits and clearances; practical assemblies and installations; and a minimum variety of structural shapes and sheet gages -- and that this airplane lacks in nothing that a high-grade military airplane should possess. Its performance is good; armament heavy; instruments and controls are adequate. Long and short-wave CW and phone radio equipment is provided.

Manufacturing Limits and Tolerances

Production economy has largely been achieved by loosening up manufacturing limits as much as possible by ingenious design. Interchangeability of wing fillets is a troublesome problem in aircraft production, as it is necessary to hold close dimensional limits on the attachment screw holes in a part that is curved in three dimensions, and extremely flexible. This problem is solved by piercing large attachment holes in the fillet itself, and using attachment strips that clamp the fillet edges between strip and wing or fuselage. This design permits drilling of attaching screw holes in strips and wing or fuselage with matched drill-jigs to insure perfect alignment, and the large holes in the fillet itself permit considerable dimensional variation of this part.

A similar problem of dimensional variations between wing tips and panels is met by special washers, screwed down over attaching holes in the skin.

The attaching holes in the tips are large enough to compensate for variations in the location of mating holes in either section of the wing.

An unusual design permits considerable fore and aft and vertical adjustment of the nose-section wing fittings for alignment at final assembly. The fitting mounting face and pad are finely serrated, and the mounting bolt holes are oversize to permit adjustment of the fitting; with shear loads being transmitted through the serrations, rather than through the bolts.

Self-Aligning Attachment Fittings

Self-aligning bushings for the majority of attachment fittings greatly simplify final assembly operations. These are also used as rod-end bearings for the engine control rods, and appear to be a standard part as their nature is such that quantity production would be a simple matter. Each bushing assembly comprises two steel parts, an outer socket ground on its I.D. to a spherical radius, and an inner bushing with its O.D. ground to a mating spherical radius. One side of the outer socket is notched with two reliefs spaced 180 deg. and slightly wider than the inner bushing. This permits assembly by turning the inner member at right angles to the outer part, slipping the two together, and rotating the inner member into line with the outer. The assembled bushing has a ball-and-socket effect, permitting angular alignment over an unusually wide range.

Interchangeability

It is obvious that the designers of the Me110 concentrated every effort upon developing a structural design so well adapted to mass production that any reasonable accelerated production schedule could be met, and one which permits manufacture of completely interchangeable major components in widely scattered shadow factories, to be later assembled at one or more centrally located assembly plants, without regard to what factory produced a particular sub-assembly.

Examination of the airframe reveals that every factor affecting production was carefully weighed during the design of the Messerschmitt, even the consideration that the majority of assembly and fabrication must be possible of accomplishment with semi-skilled labor in the event that accelerated production and the demands of military service should bring about an acute shortage of skilled labor.

Materials

The general conclusions to be drawn from chemical and physical analysis of typical parts from the Me110 indicate that metallic materials used are similar to those of American military airplanes. Slight variations in chemical composition exist, but a majority can be compared to domestic alloys -- with the principal variations representing either coservation of strategic materials, or simply the personal preferences of individual metallurgists. The use of minimum quantities of nickle, chromium, and manganese would indicate the former premise.

Non-metallic materials also are similar to those commonly used in this country, excepting paints and enamels, which are entirely different, both as to vehicle and pigments used.

Aluminum Alloys

A variety of aluminum-alloy samples from the Messerschmitt were submitted to the Aluminum Company of America for analysis. These were examined and tested by their Mr. F. Keller, and his findings as detailed in Alcoa Reports No. 138-127 and 138-127A can be summarized as follows:

The samples, in general, were of duralumin-type alloys having somewhat higher magnesium and manganese contents than Alcoa 17S alloy, but lower copper and magnesium contents than those of Alcoa 24S alloy. A majority of the sheet samples had high-purity aluminum surface coatings and duralumin-type alloy cores similar in thickness and chemical composition to Alcoa 24S. The mechanical properties of these samples were similar to those of Alcoa 24ST. The propeller blade forging was of a duralumin type alloy with high manganese. A bomb rack sample was made from an alloy of the 51S type with added manganese. Extruded sections used in the wing spar assembly were made from a high manganese content alloy of the 24S type.

Rivets were made from a low-copper duralumin-type material somewhat like 17S alloy. The rivets examined were subject to intergranular corrosion, while laboratory tests of all other samples showed these subject only to pitting-type of corrosion.

The various samples had much heavier paint coats than are normally applied to aircraft in this country. The weight of paint was 1.06 ounces per square foot in some instances. The paint pigments consisted principally of mica and zinc oxide.

Magnesium Alloys

A surprisingly small quantity of magnesium alloy parts are used in the Me110, in view of Germany's extensive magnesium production. The principal uses of the metal are the engine-mount beams, landing gear fairing, engine cowling, and miscellaneous small castings. An engine-mount beam was analyzed and tested in the Alcoa laboratories, and found to be practically identical with our AMC58S alloy. A sample of fairing tested by the Dow Chemical Company was found to be similar to their Type-M alloy sheet.

Steels

A majority of the steels used in the Messerschmitt are similar to carbon and alloy steel used in this country, excepting that the sulphur and phosphorous contents are very low-- for the obvious purpose of improving welding properties. Corrosion-resistant nickle-chrome iron alloys are not used. The nearest approach to such an alloy are the engine exhaust stacks, made from a 6.86% chrome steel, having only a trace of nickle, and none of titanium or columbium.

A majority of the high-strength steel parts are alloys similar to our SAE X4130 and SAE X4135, with some parts made from a medium chrome-molybdenum alloy similar to a grade used in England for nitrided parts and forgings, but not generally used in this country. This alloy has a composition of .33% carbon, .67% manganese, .012% phosphorus, .006% sulphur, .33% silicon, 2.32% chromium, .68% molybdenum, .28% copper, .17% vanadium, .16% titanium, and .036% beryllium.

Protective Coatings

The dope coating applied to fabric surfaces of the Messerschmitt compares favorably with American dope coatings. The one outstanding difference is the enamel applied over the doped surface to protect against ultra-violet light disintegration, and to serve as camouflage. Enamels of the oxiding alkyd-resin type have been used in this country for similar purposes, but were unsatisfactory due to disintegrated enamel leaving a film difficult to remove and impossible successfully to re-paint. The German non-oxiding type enamel used on the Messerschmitt has the advantage of easy removal with toluol without damaging the doped surfaces underneath.

The German zinc-oxide primer for metal parts is totally different from that used in this country, where zinc-chromate primer is always used for the basic corrosion preventative. Our experience has been that zinc-chromate primer gives far better corrosion-resistance and imparts better adhesion to aluminum and magnesium alloys than the zinc-oxide combinations used in the Messerschmitt primers. However, since our vehicle is so different from theirs, it is possible that their finishes provide equivalent protection.

One definite advantage of the German primer is its ease of removal, even after long ageing. Another advantage of the German primer, and also the lacquer and enamel top-coats, is their low cost. The most obvious disadvantage of the German enamels is their comparatively poor hiding power and coverage. Their use of large proportions of inert and low hiding power pigment makes necessary the application of more coats and addition of more weight to the airplane.

Cadmium plating is apparently not considered necessary by German engineers. Instead, an extra heavy coat of paint is used in places where American practice would cadmium plate. Other steel parts are protected by inexpensive black enamel. The effectiveness of paint alone for the protection of steel parts is surprising, as comparatively little corrosion of steel parts is evident; considering the long, unprotected ocean voyage made by this Me110 during shipment between England and California.

Threaded and Pinned Fastenings

The various threaded and pinned fastenings used by the Me110, such as screws, bolts, and rivets, are somewhat different from those of American airplanes, and merit separate discussion. For example, taper pins are rarely used, and a majority of rod ends are attached with tubular rivets.

Screws

Screws and nuts used to assemble the cockpit enclosure are a distinctive type. The head of the screw resembles a brazier-head rivet and is not slotted. The nut is a short length of steel tubing, slotted at one end to receive a screw driver, and is about four diameters in length. A lock washer is used under the nut.

All screws are the slotted type, and a 90 deg. head is used on a majority of countersunk screws.

Nut-Plates

The German version of our AC366 steel nut-plate appears to be more expensive, although weighing less. This nut-plate consists of a dural housing of a shape and size similar to AC366, and a threaded steel insert. This insert is tapered and has a 1/16 in. wide longitudinal sawcut through one side. The housing bore is tapered, and has a tongue to enter the sawcut and prevent the insert from turning. A duralumin nut-plate having a fibre insert similar to a "stop-nut" is used in a few places.

Rivets

Countersunk rivets use a 100 deg. head, and are used to produce dimples wherever the sheet thickness permits. Steel rivets of peculiar construction are used to attach the wing main-attachment fittings to the monospar. These fittings are counterbored about 9/16 in. dia. by 3/32 in. depth at each rivet location. The rivets are heat-treated steel and completely machined to form a rivet having a cylindrical head, and counterbored 1/4 in. deep at the driven end to produce a 1/32 in. thick wall. The approximate dimensions of these rivets are 13/32 in. dia. shank, with a head 9/16 in. dia. and 3/32 in. high.

The rivet is used by placing a washer 13/16 in. dia. by 1/8 in. thick (having a hole 1/32 in. larger than the rivet shank) over the driven end after inserting the rivet, and then expanding the 1/32 in. wall at the shank end with a spinning tool. Explosive rivets are not used on this airplane.

The rivets for attaching fabric tacking strip to trailing edge ribs are inexpensive, yet efficient, and each consists of four parts made as very thin steel stampings. These are arranged into two assemblies, with each assembly consisting of a head and a shank. The shank end of one assembly is open, and the shank of the other closed. One assembly telescopes into the other at assembly, and small head is produced on the closed-end shank by squeezing the two assemblies together.

Clevis pins are not used on the Me110. Instead a bolt, washer, nut, and cotter pin are used for a majority of clevis connections.

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WING

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Chapter 2

WING

The Messerschmitt Me110 uses a monospar wing structure, essentially comprising two panels attaching directly to a truss structure built within the fuselage framing. A single spar, at 38.75% chord, extends the full length of each panel, with two sub-spars extending between wing root and engine nacelle to carry torsion loads around the nacelle cut-out and to support the fuel tanks. Weight economy is obtained by avoiding abrupt structure changes

The wing plan form is a straight taper, with a span of 53 ft. 5 in., an area of 414 sq. ft. and an aspect ratio of aproximately 7.3:1 The taper ratio is 2.7:1, and the dihedral angle on the lower surface of the wing is 5½ degrees A fairly thick ratio of root thickness to chord of 0.185 is used, and the structure weight is 4.8 lbs/sq ft

Wing Spars

The tapered cap strips for the main spar are built-up from extruded angles and aluminum-alloy plate strips, with tapered steel-strip cap plates extending outboard 145 inches from the wing root The spar is highly shear resistant, with very light vertical stiffeners being used only at rib stations. The shear-web is 0.125 thick at the root, and is reduced to .045 at the tip by a process of several decreasing steps. Near the tip where the bending stress is reduced, the extruded angle cap strips are replaced by forming the shear-web into a channel section.

Editor's Note: The technical data for this portion of the Messerschmitt Analysis was contributed by Mr. R. Breitbarth, Group Leader in Charge of Wing Design for the Engineering and Development Department of Vultee Aircraft, Inc.

Two sub-spars extending between engine nacelle and wing root at 4% and 68% chord provide structure for secondary bending between nacelle and fuselage, and for torque connection at the wing-to-fuselage attachment. The forwrd sub-spar consists of a sheet metal web with formed-angle cap strips and formed Z-section stiffeners. The rear sub-spar is a formed-channel with thin-gage angle stiffeners.

A curved trailing-edge fairing closes the aft portion of the wing and serves as a fairing for both flap and aileron. This section is continuous from root to tip.

Rib Construction

The principal structural ribs aft of the main spar are truss type, with formed Z-section rib caps and flanged channel-section diagonals. Two identical channels are riveted back-to-back in highly loaded areas. While a majority of structural ribs are truss type, there are several lightly loaded ribs of conventional stamped or pressed design. Formed Z-section stiffeners of .032 in. material are located between the ribs. All ribs and formers are spaced approximately 10 in. on center.

Stamped or pressed nose ribs fabricated from .032 in. sheet are used forward of the main spar. These ribs are made in two pieces and riveted together along the chord line during final assembly of the wing. This procedure eliminates the necessity of holding the rib contours to close limits.

Stringers

A majority of the spanwise stringers are hat sections of .045 in. material. Four stringers are used on the upper surface, while only one is used on the lower surface. These stringers are flattened where they intersect the ribs, (thus maintaining the same area but reducing the moment of inertia) and are without attachment between stringers and ribs. The upper, forward stringer extending from Sta. #109 to the wing tip, differs by being a steel channel of .085 in. material.

Wing Skin

The wing skin is aluminum-alloy sheet varying in thickness from .032 in. at the tip to .082 in the region of the engine. All external rivets are flush-type, of either 1/4 or 3/16 in. diameter, with punch countersinking being used extensively. Chordwise skin joints are lap-type, and spanwise joints are butt-type. Only three spanwise joints are used: (1) at the main spar upper. (2) lower cap strips; and (3) at the trailing edge. Rivets are used rather sparingly throughout the entire wing structure, excepting at the skin splices.

Wing Tips

Each wing tip assembly consists of a single curved stamping reinforced by a conventional stamped rib. These two parts are riveted together, and the unit attached to the wing structure by means of flush screws. The attaching screw holes in the tip are oversize to allow for manufacturing tolerances. Provision is made in each tip for a navigation lamp.

Miscellaneous Structural Details

The wheel well lining, in accordance with the present design trends, consists of fabric laced to the surrounding structure. Access to internal structure adjacent to the wheel well is through zipered openings in the fabric.

Access to the structure for repair and maintenance is provided by numerous removable doors and covers in the lower surface of the wing.

Tie-down fittings are located on the wing lower surface, well toward the tip. These are of the exposed eyelet type, with no provision made for either their streamlining or removal.

Extrusions have been sparingly employed throughout the wing, being used only for the main spar caps and for a few reinforcements; with rolled or drawn sections used wherever possible.

Small bent-up gussets and doubler plates are freely used. Flanges on doublers and gussets rarely extend beyond the bend radius of the material which is contrary to American practice.

A minimum variety of structural sections are to be seen, with two sizes of flanged channel-section being used for all rib caps, stringers, stiffeners, and access door reinforcements.

Wing Attachment Fittings

The wing-to-fuselage attachment is made at four points, with the main fittings located at the main-spar upper and lower caps. Auxiliary fittings near the nose and trailing edge provide torque connection.

The lower main connection consists of a clevis fitting attached to the fuselage wing truss, and a mating lug fitting attached to the wing spar lower cap. The lug portion carries a self-aligning bushing to eliminate close manufacturing limits. The bolt used for this connection is 1-7/8 in. dia.

The upper main attachment at the upper spar cap is a blade-like section at the outboard end and changes into a 1-5/16 in. dia. threaded stud at the inboard end. The blade end is riveted between wing skin and spar cap. The stud-end fits into a flanged steel bushing attached to the fuselage wing truss.

The fore and aft torque connections are clevis joints similar to the main-spar lower attachment. These fittings attach to the fore and aft sub-spars and each consists of four main units: (1) a threaded clevis fitting attached to the wing ; (2) a lug fitting attached to the fuselage; (3) a retaining collar; and (4) an 11/16 in. dia. nut and bolt.

The wing attachment fittings on the fuselage are unique by virtue of incorporating provisions for hoisting the airplane. The forward fitting has an additional sheave-fitting to receive a hoisting line assembled over the attachment fitting as a permanent part of the airplane. The lower portion of the rear fitting is grooved to receive a hoisting line. All fittings are steel, and all lug-fittings are provided with self-aligning bushings. The front fitting has an unusual feature in the form of a serrated plate riveted to the fuselage to serve as a base for the wing-attachment fitting. The fitting proper has mating serrations and oversize holes for the attaching bolts. The serrations on both parts match when the fitting is assembled on the fuselage, and carry shear loads when the bolts are tightened: permitting the oversize bolt holes to provide alignment adjustments.

The landing gear is attached to the wing at three major points. The two main fittings attach to the forward sub-spar, while the knee-strut attaches to the main spar. Heavy truss type ribs are provided in the region of the landing gear.

Fuel Tank Compartments

The main fuel tanks are located at the inboard end of the wing panel, one forward and one aft of the main spar, with access provided through large removable covers on the wing lower surface. These covers are attached to the structure by machine screws spaced on approximately 2-inch centers, and each consist of a flat sheet reinforced by rolled stiffeners and a sheet-metal frame extending completely around the cover. Three-eight inch diameter pins attached to each corner of the cover fit mating sockets in the wing structure to carry the shear load, with the screws holding the cover in place. The upper surface of the fuel compartment is reinforced by closely spaced chordwise stiffeners and spanwise stringers, joined at intersections with gussets.

Each tank is supported in a non-metallic frame by fabric straps, with the obvious intent of avoiding damage from metal "orange-peel" caused by bullets.

Two 1-1/2 in. wide fabric straps pass across the top and two 4 in. wide cotton web straps across the bottom.

The phenolic-fibre frame is of oval section, having a major diameter of about 3 in., and a 1/2 in. minor diameter. This frame is positioned near the top of the tank, and extends entirely around the rectangular tank. The frame has four fibre corner blocks placed approximately 12 in. from each end of the tank. These corners serve as junctions for the strap slings and also fasten the tank to the wing structure.

Each corner block has a hollow stud for attachment to the wing structure. The structure adjacent to the top skin is reinforced at the tank attachment points, and adequate fittings are provided to fasten the tank in place. An access door is provided in the skin at each attachment point.

Aileron Structure

The ailerons are slotted-type, fabric covered, and constructed along conventional lines. The nose section is formed sheet of .035 aluminum-alloy which extends back to a spar located at approximately 20% of the aileron chord. This spar extends the full length of the surface, and consists of a simple flanged-web with spanwise plates nested inside the flanges to provide additional bending resistance. This combination of metal leading edge, and full-span spar provides a rigid torque-box.

The aileron ribs are fabricated of .030 gage sheet metal with circular flanged lightening holes, and are either stamped or pressed to shape. The attachment of ribs to spar is accomplished by formed angles riveted to both parts. A wedge-shaped seamless aluminum-alloy tube is used as a trailing edge strip, with small tapered magnesium blocks inserted into slots in the trailing edge tube at each rib intersection, and riveted to tube and rib.

The method of fabric attachment differs from American practice in using linen-strips riveted to the ribs as the attaching medium, and sewing the covering fabric to the linen strips. Distortion of the end-ribs by the shrinking of doped fabric is prevented by channel-section stiffeners attached to these ribs.

Aileron Hinges

Each aileron is hinged at the ends and center, with the hinge bracket forgings attaching directly to rib structure, without benefit of an aileron spar. The surface is operated by an actuating lever combined with the center hinge, and the inboard aileron hinge provides for both the aileron and the outbaord end of the flap. All hinge bearings are of the exposed ball-bearing type without integral dust shields.

Aileron Balance and Trim

The aileron is statically balanced by two concentrated external, streamlined, balance weights. A trim tab is installed at the inboard end of each aileron. This tab is not adjustable in flight, but is adjustable for trim on the ground.

Wing Flaps and Slats

The wing flaps are the slotted type, and similar to the ailerons in construction. Each flap is fabric covered, excepting the inboard, lower surface which carries the aft portion of the landing gear door fairing. Each flap is hinged at three places and is operated from its inboard end. The inboard and center hinge brackets are flat plate-stock machined to shape, and carry ball bearings similar to those for the aileron hinges.

The wing is fitted with automatic leading edge slots similar to the well-known Handley-Page slotted wing. A slat hinged at two points extends inboard from each tip for a distance of 127 in., and consists of a heavy-gage sheet-metal skin held in shape by small stamped-metal ribs.

WING

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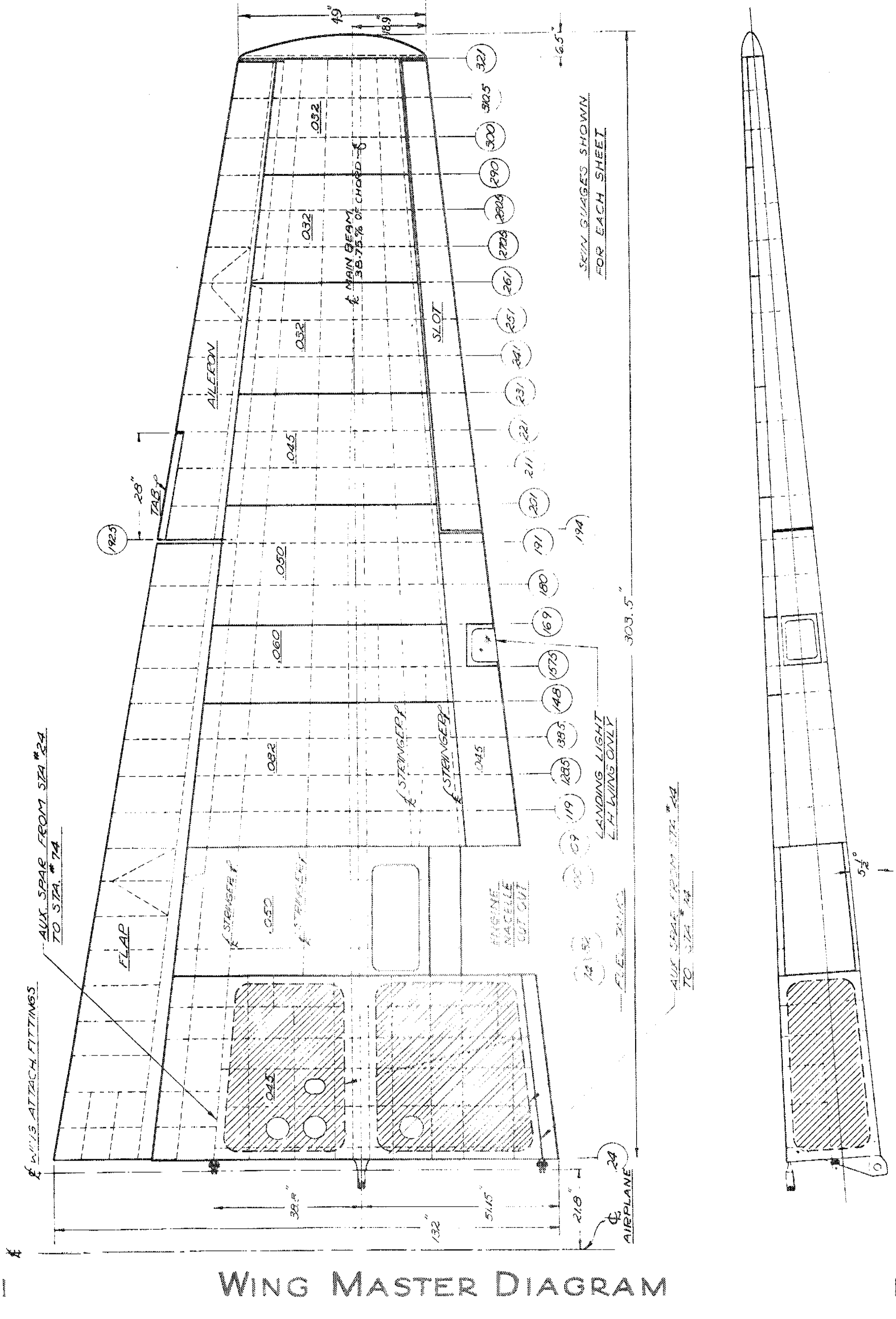

Fig. 1 WING MASTER DIAGRAM Fig. 1

WING

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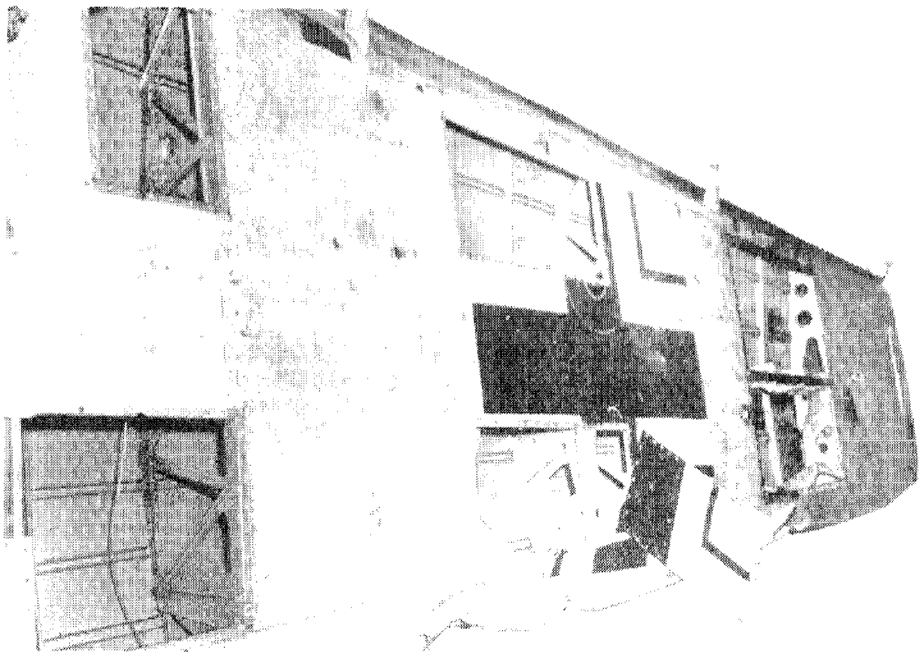
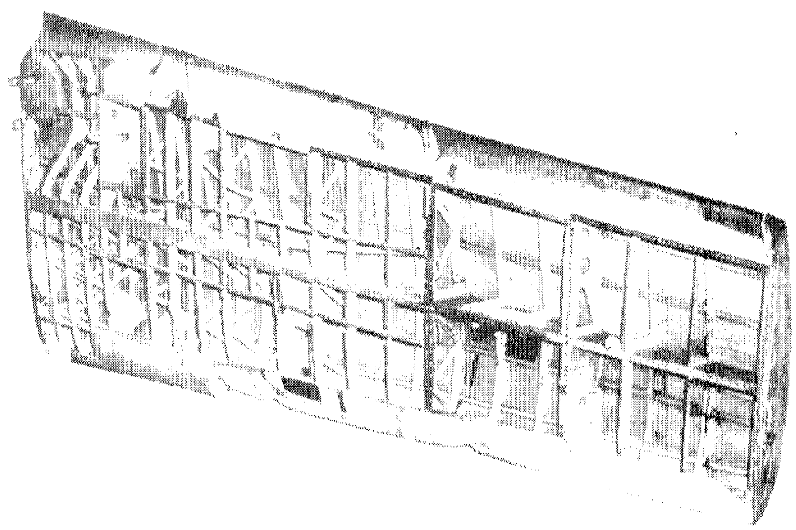


SKINNED – ACCESS PANELS REMOVED



UNSKINNED

FIG. 2 **WING STRUCTURE** FIG. 2

WING

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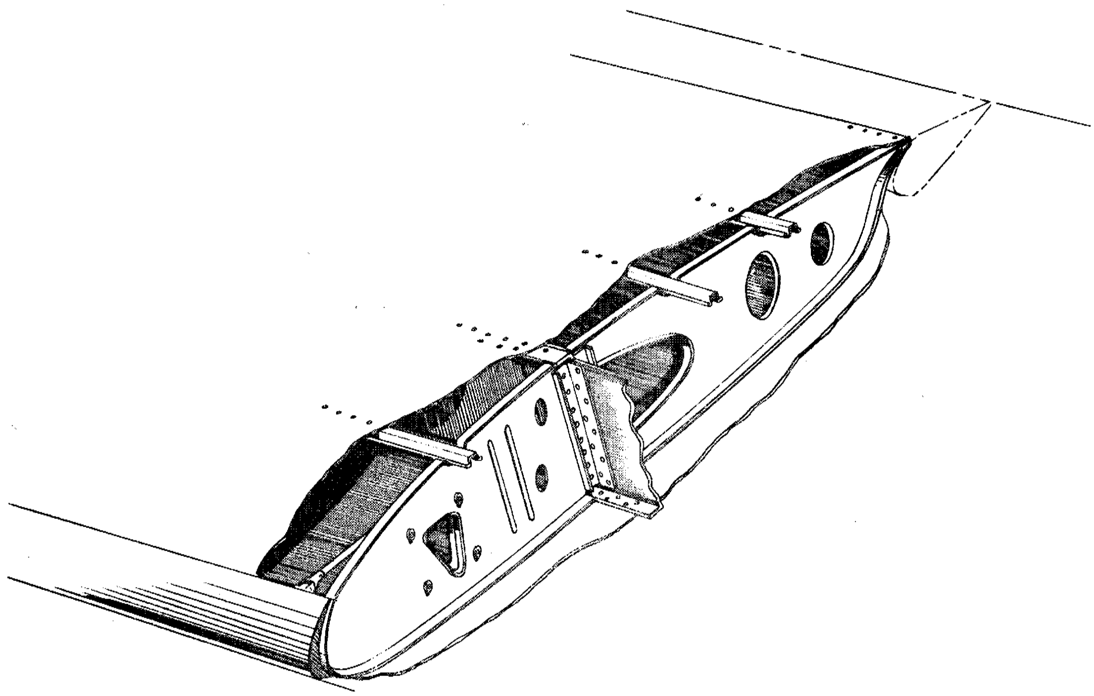
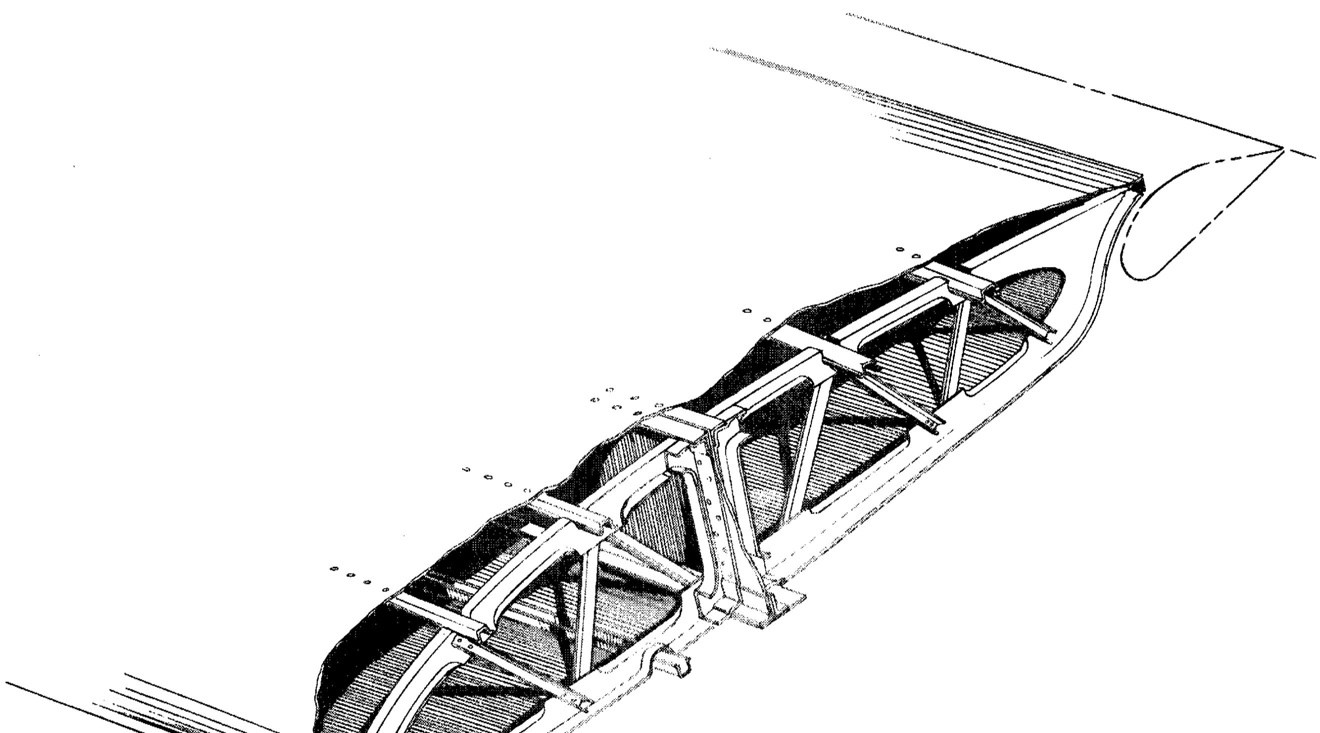


TYPICAL FORMED RIB



TYPICAL BUILT-UP RIB

FIG. 3 **TYPICAL RIB STRUCTURE** FIG. 3

WING

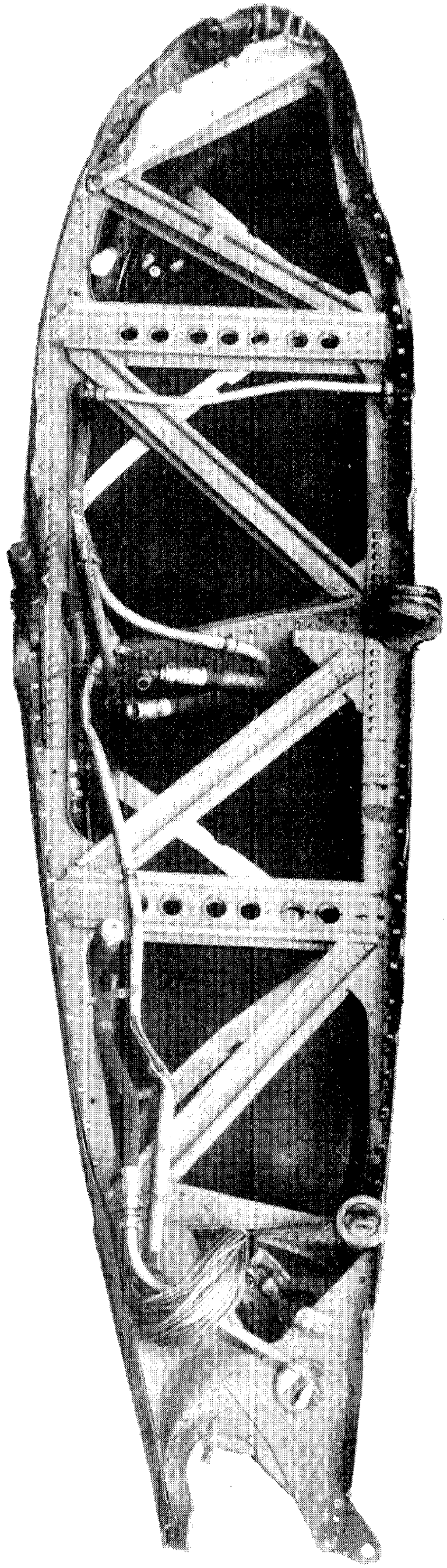


FIG. 4 WING PANEL INBOARD RIB FIG. 4

WING

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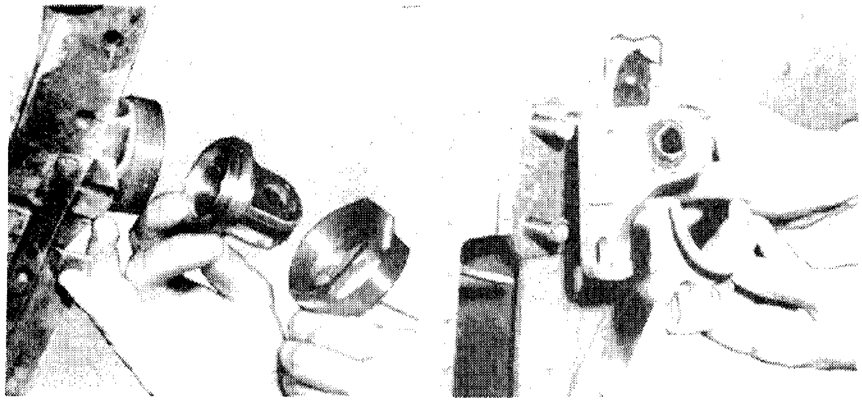
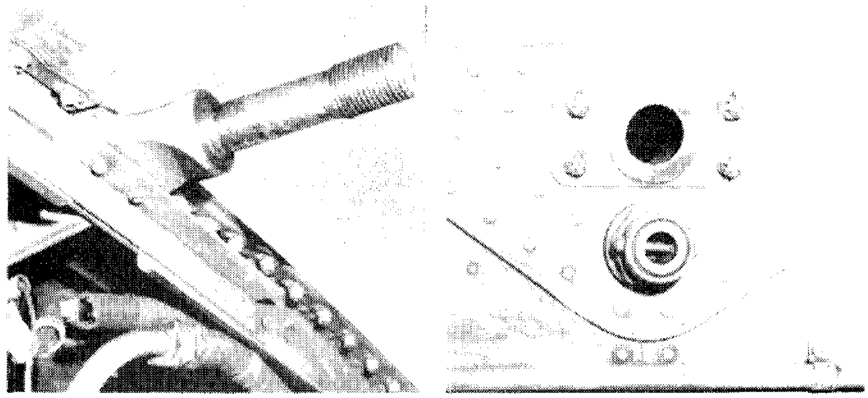
FRONT FITTING



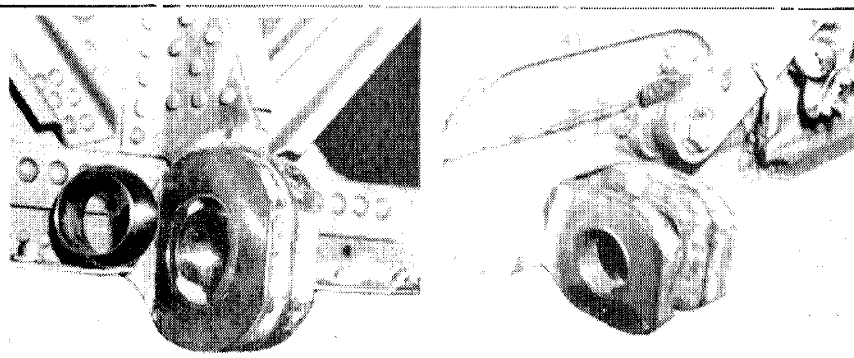
LEFT — WING UNIT
RIGHT — FUSELAGE UNIT

UPPER MAIN FITTING 38.75% CHORD



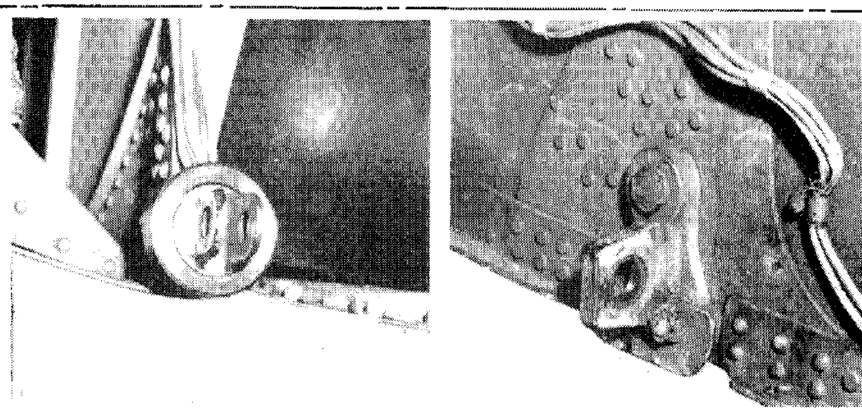
LEFT — WING UNIT
RIGHT — FUSELAGE UNIT

LOWER MAIN FITTING 38.75% CHORD



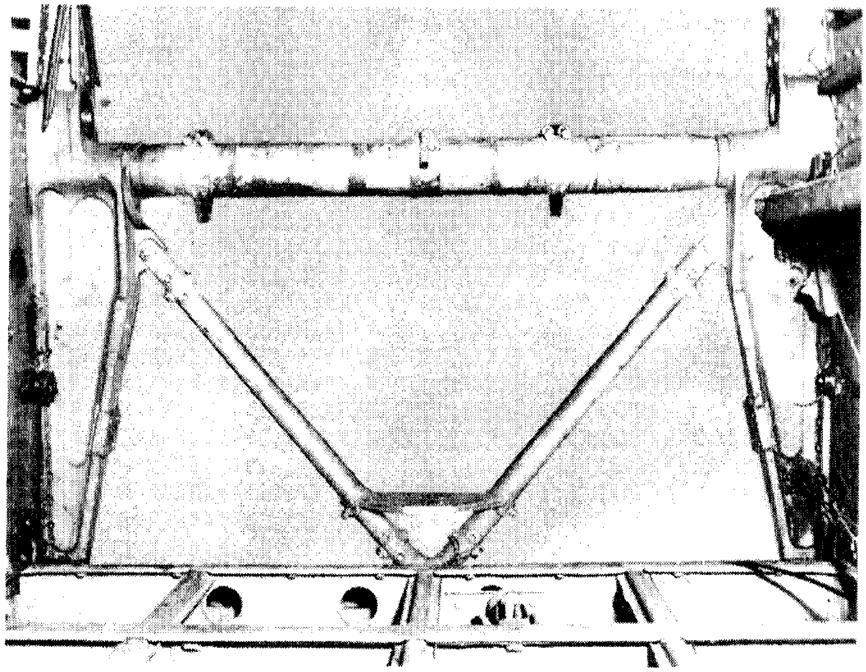
LEFT — WING UNIT
RIGHT — FUSELAGE UNIT

REAR FITTING



LEFT — WING UNIT
RIGHT — FUSELAGE UNIT

FIG. 5 WING ATTACHMENT FITTINGS FIG. 5



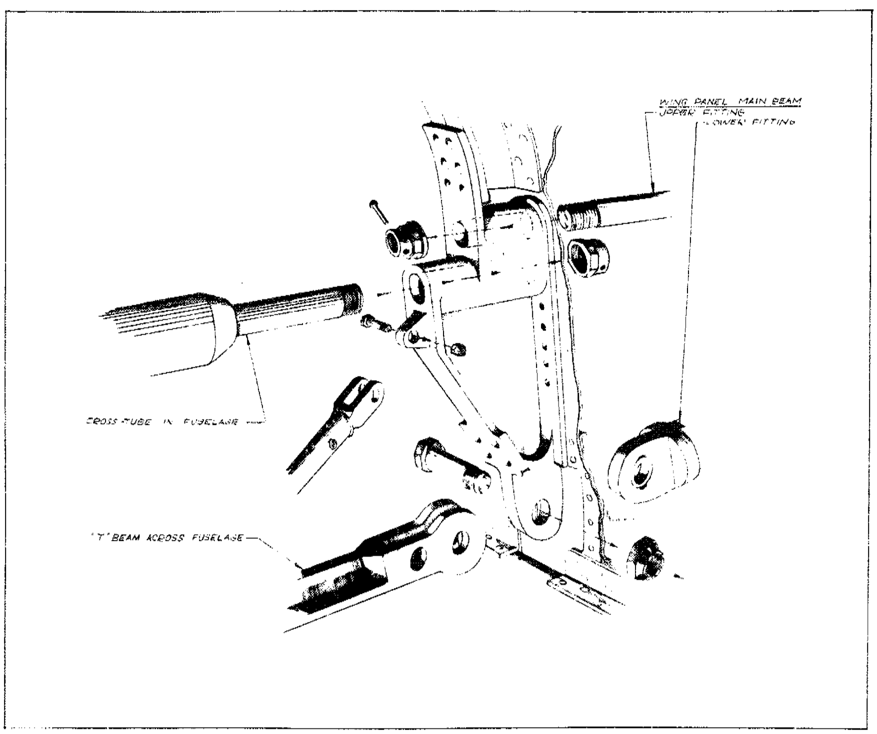


Fig. 6 WING MAIN BEAM TRUSS IN FUSELAGE Fig. 6

WING

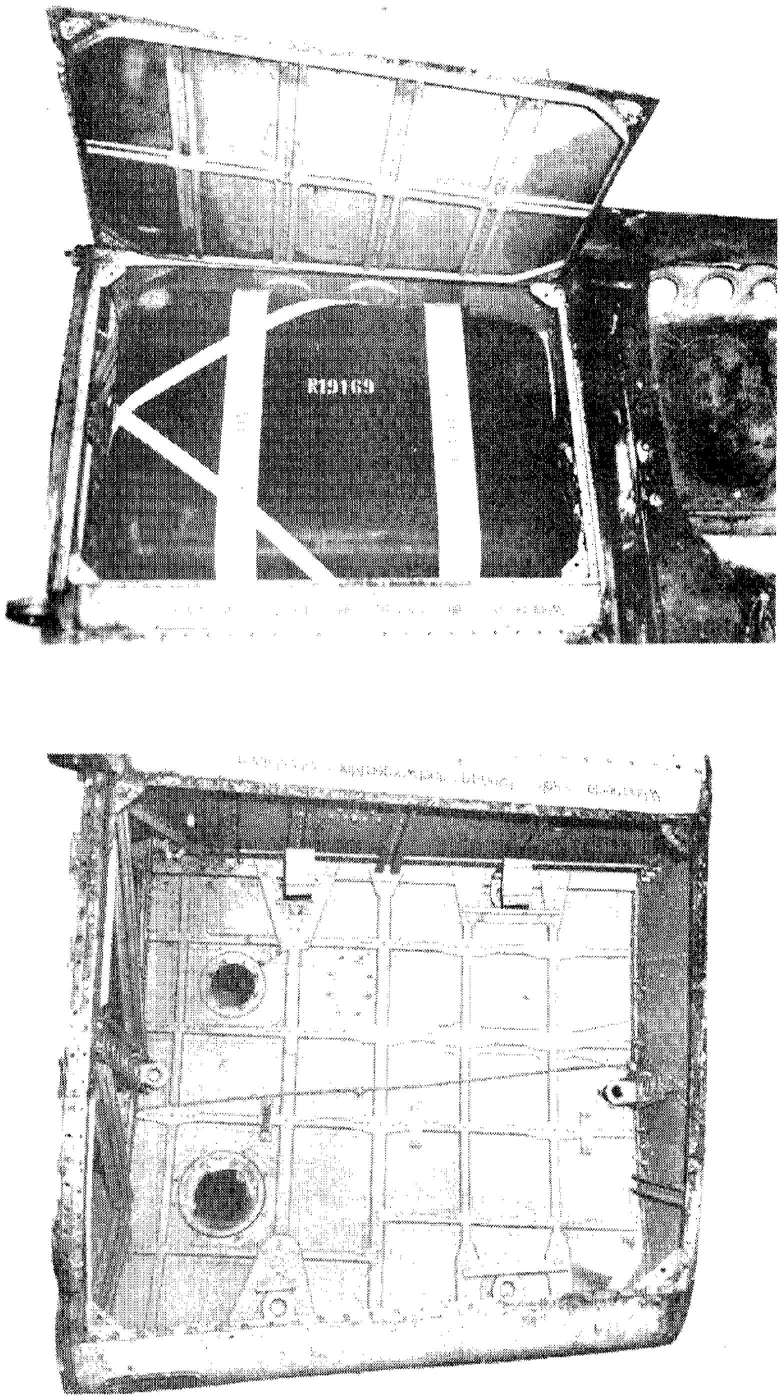


FIG. 7 FUEL TANK COMPARTMENT FIG. 7

WING

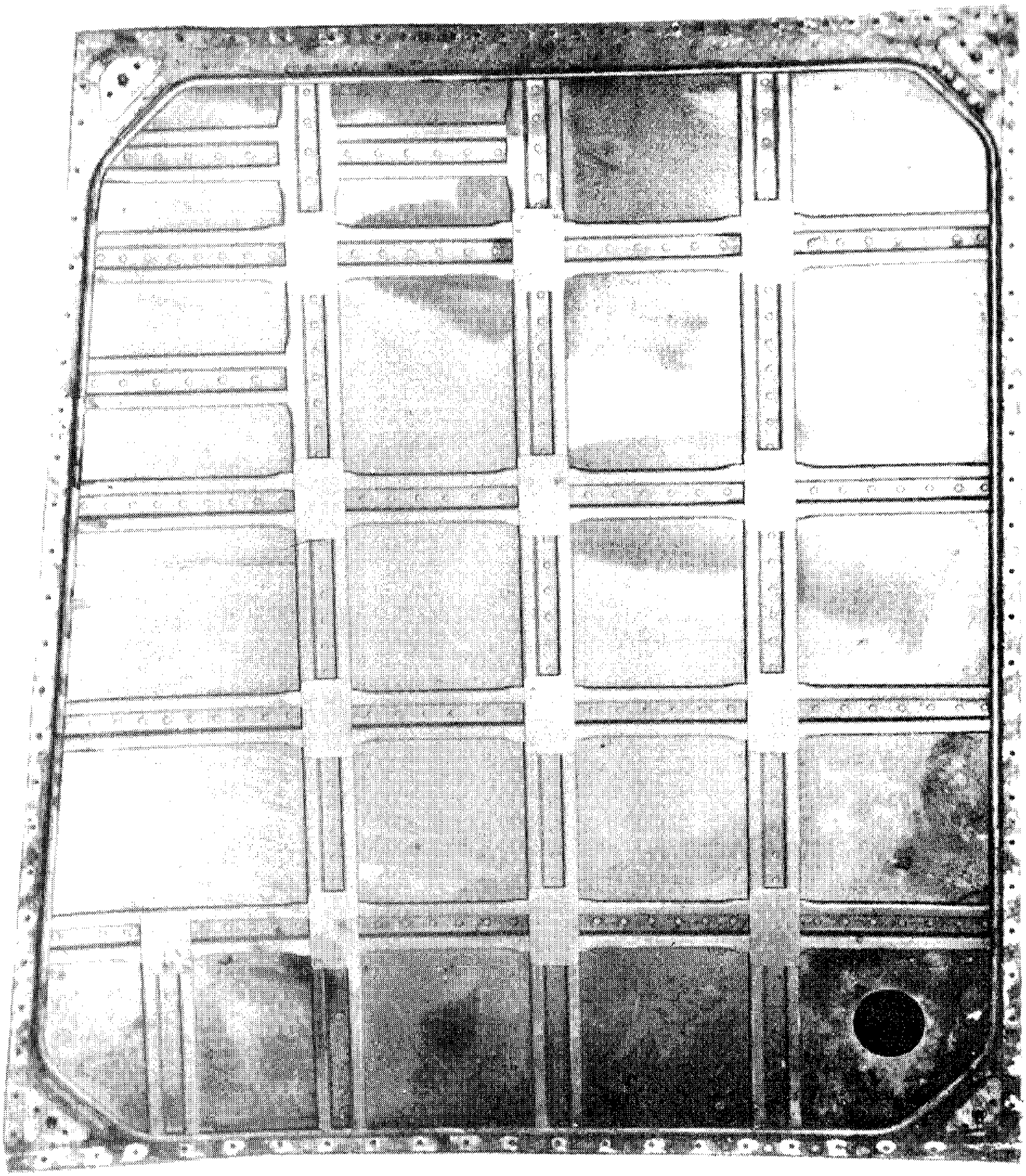
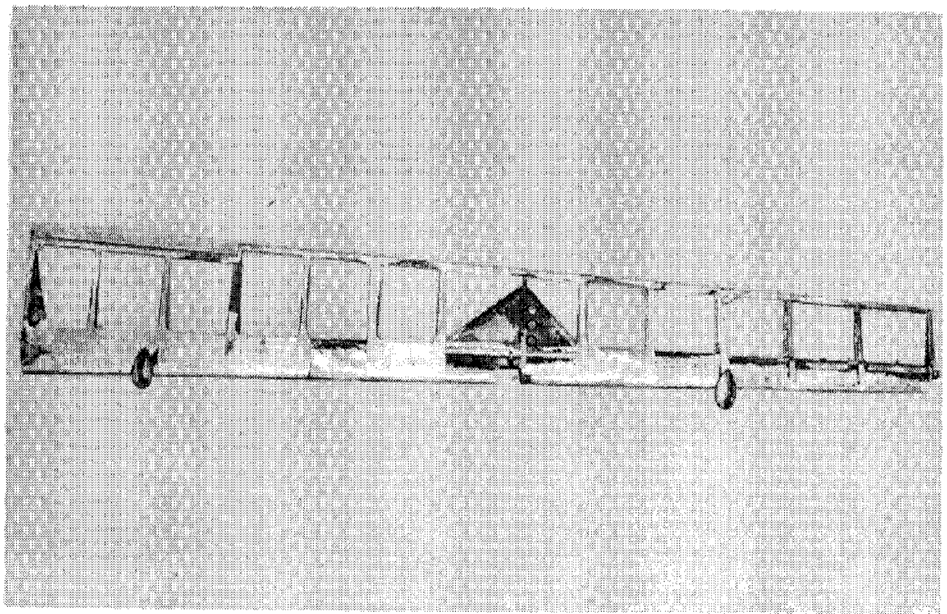


FIG. 8 FUEL TANK COMPARTMENT COVER PANEL FIG. 8



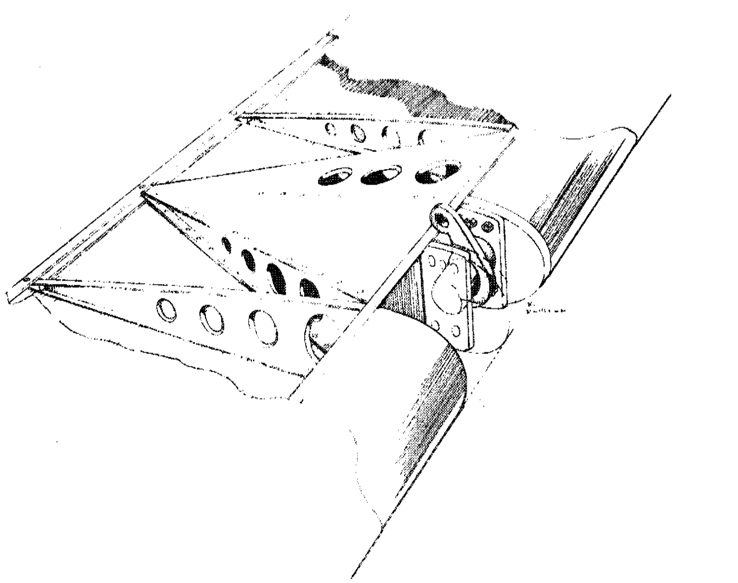


Fig. 9 AILERON & HINGE STRUCTURE Fig. 9

Chapter 3

EMPENNAGE

Chapter 3

EMPENNAGE

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C h a p t e r 3

E M P E N N A G E

The empennage design of the Messerschmitt Me110 is somewhat similar in configuration to that of modern Lockheed transport airplanes. Its detail structure is quite different from any used in this country -- particularly in the construction of the fixed surfaces, and in the use of an adjustable stabilizer to trim the airplane automatically for flaps-down landings.

Horizontal Stabilizer

The horizontal stabilizer is symmetrical, straight tapered 1.21:1, with a ratio of root-thickness to chord of 0.107 (approximately 10%). It is adjustable and interconnected with the flaps to lower the leading edge of the stabilizer approximately two inches 4-1/2 deg. incidence when the flaps are lowered. Attachment to the fuselage is by three bolts through self-aligning bushings and pin-jointed fittings arranged in a triangular pattern. Two of these fittings are near the stabilizer rear spar, and the third or front fitting is connected to the screw-jack mechanism for adjusting the horizontal stabilizer.

The construction of the stabilizer can best be understood by visualizing a conventional structure of front and rear channel-section beams, pressed ribs, and cover sheets being sliced along the chord line to give an upper and a lower half; the cut edges of the ribs, beams and leading edge skin in each half then being provided with flanges so that each becomes a "Z" section. These halves are placed together, and the entire outside edge riveted through the mating flanges of the "Z" sections and the nose skin, with the flanges of the main spar

Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. R. Degenfelder, Group Leader in Charge of Empennage Design for the Engineering and Development Department of Vultee Aircraft, Inc.

being joined by bolts inserted through holes pierced in the upper and lower skin sheets. Cloth patches are doped over the bolt access holes, and a small cast magnesium nose-piece is attached over the flanges in the leading edge skin with flush screws.

Since the stabilizer consists of two symmetrical halves the following description is confined to one of the halves: The structure is a mono-spar design, with the spar located at approximately 40% chord and parallel to the elevator-hinge centerline (64% chord), and comprising two extrusions (0.208 thick) riveted back-to-back to an 0.188 thick web. This spar tapers uniformly into a bent up "Z" section formed by a continuation of the spar web. A forged corner-fitting is riveted to the spar web at each Sta. #6 rib to provide support for the stabilizer aft attaching-fittings. A Z-section stringer is located at 59% chord as a closing member for the aft end of the structure, and is not designed to take primary bending loads, as it is spliced at Sta. #0 and cut by the concentrated balance weights. The front stringer is in three span-wise sections: a center member located on 15.1% chord and extending to left and right-side Stations #25; and two outboard members which extend outward and aft to points 6-3/8 in. forward of the main beam at left and right-side Stations #70. The center member is a formed Z-section, and the respective halves are riveted together only between left and right-side Stations #9. The outboard members each consist of a formed Z-section riveted to a formed cap-angle along the skin contour. The stabilizer front-attachment fitting is riveted between ribs placed back-to-back at Station #0, and projects through a cutout in front stiffener web.

Two types of ribs are used: One is a hat-section stiffener identical with the fuselage stringers and vertical stabilizer stiffeners; while the other is a complete Z section rib. However, except for the end-ribs, the respective halves of the complete ribs are not joined.

The spacing of ribs and stiffeners is approximately 9 in., giving a maximum unsupported skin panel of 9 by 16 in. The hinge ribs are formed hat-sections with the hinge fitting bolted between the upper and lower members. Holes in upper and lower skin provide bolt access.

The skin comprises two formed sheets (.048 in.) spliced at Sta. #0 by a double row of rivets. A formed angle riveted to the skin's aft edge provides stiffness. All edges throughout the stabilizer assembly are provided with either an integral or riveted stiffener flange. The weight of the horizontal stabilizer is 122.1 lbs. or approximately 2.77 lbs/sq.ft.

Vertical Stabilizer

The vertical stabilizer is an all-metal, stressed-skin structure similar to the horizontal stabilizer having an irregular shape closely approximating an elipse. The ratio of root thickness to chord is approximately 0.08, which is slightly thinner than American practice.

The vertical stabilizer is also built in two symmetrical halves, but differs from the horizontal stabilizer in using two-spar construction, with the front spar comprising a formed Z-section parallel to the rudder-hinge centerline at approximately 33% chord. The rear spar is also a formed Z-section, and is located parallel to and 8-1/2 in. aft of the front spar at approximately 50% chord. The attaching fitting rib and the end closing ribs are the only full-depth ribs in the structure. These ribs are formed Z-sections riveted together at assembly of the stabilizer halves. Hat-section stiffeners are spaced approximately 10 in. on center between the full-depth ribs. Each skin sheet is a single stamping having a flange formed around the leading edge for riveting the sheets together at assembly. A formed angle provides stiffness at the aft edge of the skin sheets.

The vertical stabilizer lower tip is a stamping, while the upper tip is a gas-welded assembly, and both are attached with flush screws. A micarta block bolted to the upper tip leading-edge provides antenna attachment.

The vertical stabilizer front attachment is by two eye bolts through fittings on the aft face of the front-spar web. The bolt eyes straddle a boss riveted to the horizontal stabilizer main spar, and a single bolt passed vertically through bolt eyes and boss completes the attachment. The rear attachment consists of a conventional pin-joint, with a self-aligning bushing incorporated in the lug-fitting.

Left and right-side vertical stabilizers are interchangeable by replacing the tab control support bracket and rear stabilizer-attaching bracket. The weight of the vertical stabilizer is 25.25 lbs. or 2.59 lbs/sq.ft.

Elevator

The elevator contour is a straight taper from nose radius to trailing edge. The trailing edge is straight tapered with the outboard end cut to clear the rudder extreme position, and the nose section is a radius about the hinge centerline. Static and dynamic balance is obtained by concentrated steel weights located at left and right Stations #46.25. Aerodynamic balance is lacking, except for a servo-acting tab. The weight of each elevator including tab is 26.0 lbs. or 2.27 lbs/sq. ft.

The elevator construction is conventional: except that the ribs are full contour, and the spar consists of intercostals riveted to nose skin and ribs. The ribs are conventional "C" channels with lightening holes in the webs, and are spaced on approximately 9 in. centers. The trailing edge is streamlined tubing opened at each rib to receive an attaching block riveted to the rib flanges. The fabric covering is sewed to cloth tacking strips attached along the ribs with special tubular rivets.

Torque tube attachment is by riveted connection between an integral flange at the tube's outboard end and the closing rib, and is not designed for bending loads; as these are apparently taken out as deflection of the closing rib web. The torque tubes join at Sta. #0 by bolting control lever and hinge support between integral flanges on their inboard ends. The intermediate hinge is a link-and-pin design, with the link being bolted between the two ribs forming the torque pyramid around the nose-skin cutout. The outboard hinges are mounted in a conventional manner on the end of the elevator, with the hinge bolt in single shear. Self-aligning bearings are used at all hinge points. The left and right elevator frame assemblies are interchangeable by replacing the tab control support-bracket.

Elevator Tab

Each elevator is provided with a combination trim and balance tab. comprising a single skin sheet wrapped around three tapered-block ribs and riveted along the trailing edge. A ball bearing is ring staked into each end rib, and a pin carried by a fitting riveted to the elevator rib projects into the tab bearing to complete each hinge. The hinge pins are not accessible after the elevator is covered, and tab replacement requires cutting a hole through the fabric covering to register with an access-hole in the structure around the tab hinge.

The tab center hinge is similar to the elevator inboard hinge support. The control lever is integral with the movable portion of the hinge and is pinned to a socket in the solid center-rib. Left and right tab assemblies are interchangeable by replacing the control lever. Each tab weighs 1.3 lbs. or 1.34 lbs/sq.ft.

Rudder

The rudder trailing edge is irregularly shaped to closely approximate an ellipse, with the leading edge being a radius about the hinge centerline.

Static and dynamic balance is obtained by a concentrated steel weight located 4-3/4 in. above the centerline of the horizontal stabilizer. The area forward of the hinge line at the top of the rudder is utilized for aerodynamic balance. Each rudder weighs, complete with tab, 16.5 lbs. or 2.53 lbs/sq. ft.

The construction of the rudder is similar to the elevator. The upper and lower hinges are similar to the elevator inboard hinge, and the rudder intermediate hinge incorporates the control lever. This lever is made from 1/4 in. thick plate to receive the pressed-in bearings for hinge and control push-pull tube, and with a tapered spacer on either side is bolted between the ribs forming the torque pyramid around the nose skin cutout. The left and right rudder frame assemblies are interchangeable by replacing the control lever. The portions of the rudder above the upper hinge and below the lower hinge are formed sheet metal tips, beaded for stiffness, and riveted to the hinge ribs.

Rudder Tab

The rudder tab is for trim only, and its structure is identical to that of the elevator tab. Due to the small section at the hinge centerline, the bearings are mounted in fittings on the rudder frame, and 1/8 in. steel wire passes the full length of the tab to form the hinge pin. Left and right-side tab assemblies are interchangeable, and weight, including fittings, 0.40 lbs. each, or 1.35 lbs/sq.ft.

EMPENNAGE

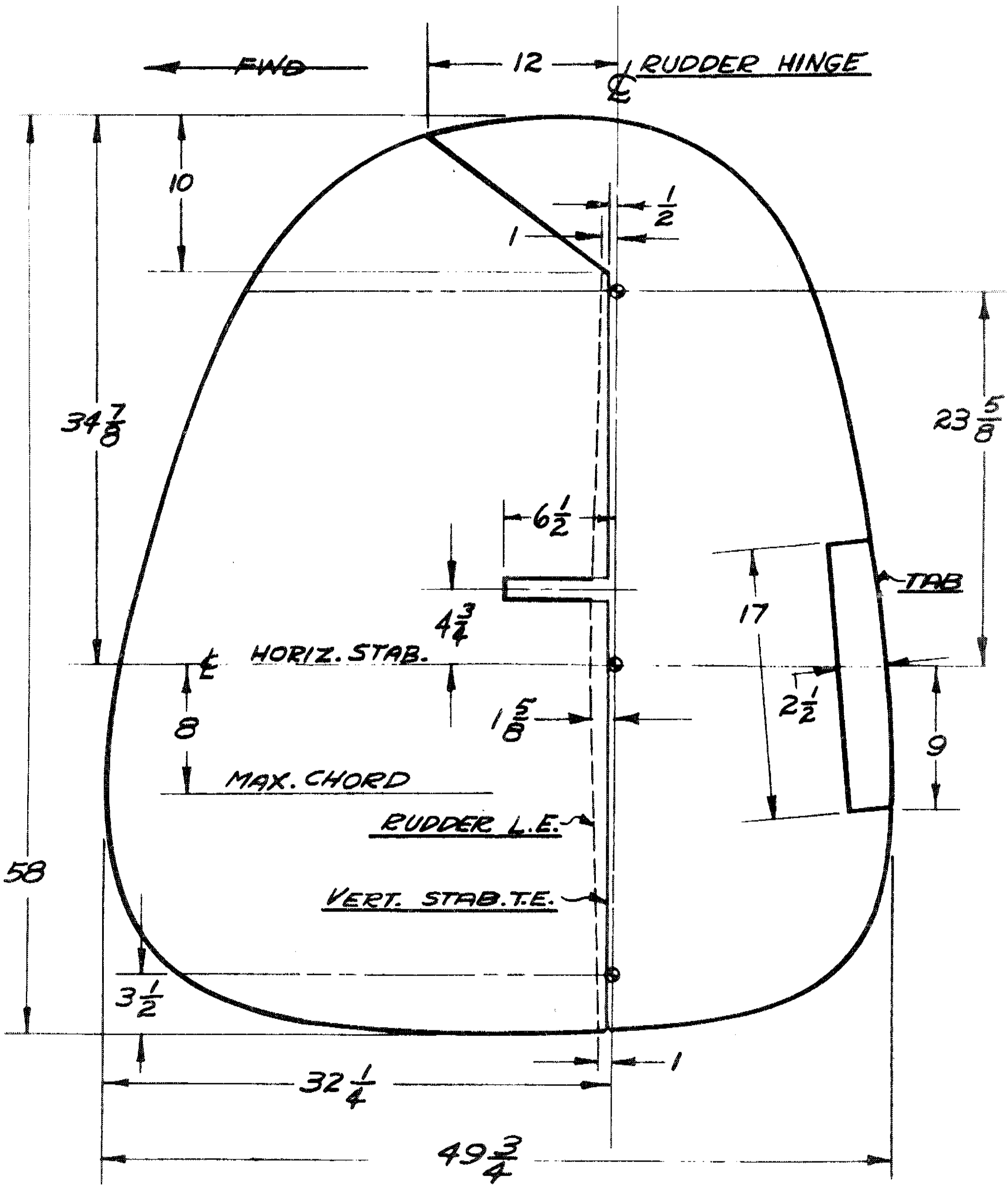

FIG. 1 VERTICAL SURFACE MASTER DIAGRAM FIG. 1

EMPENNAGE

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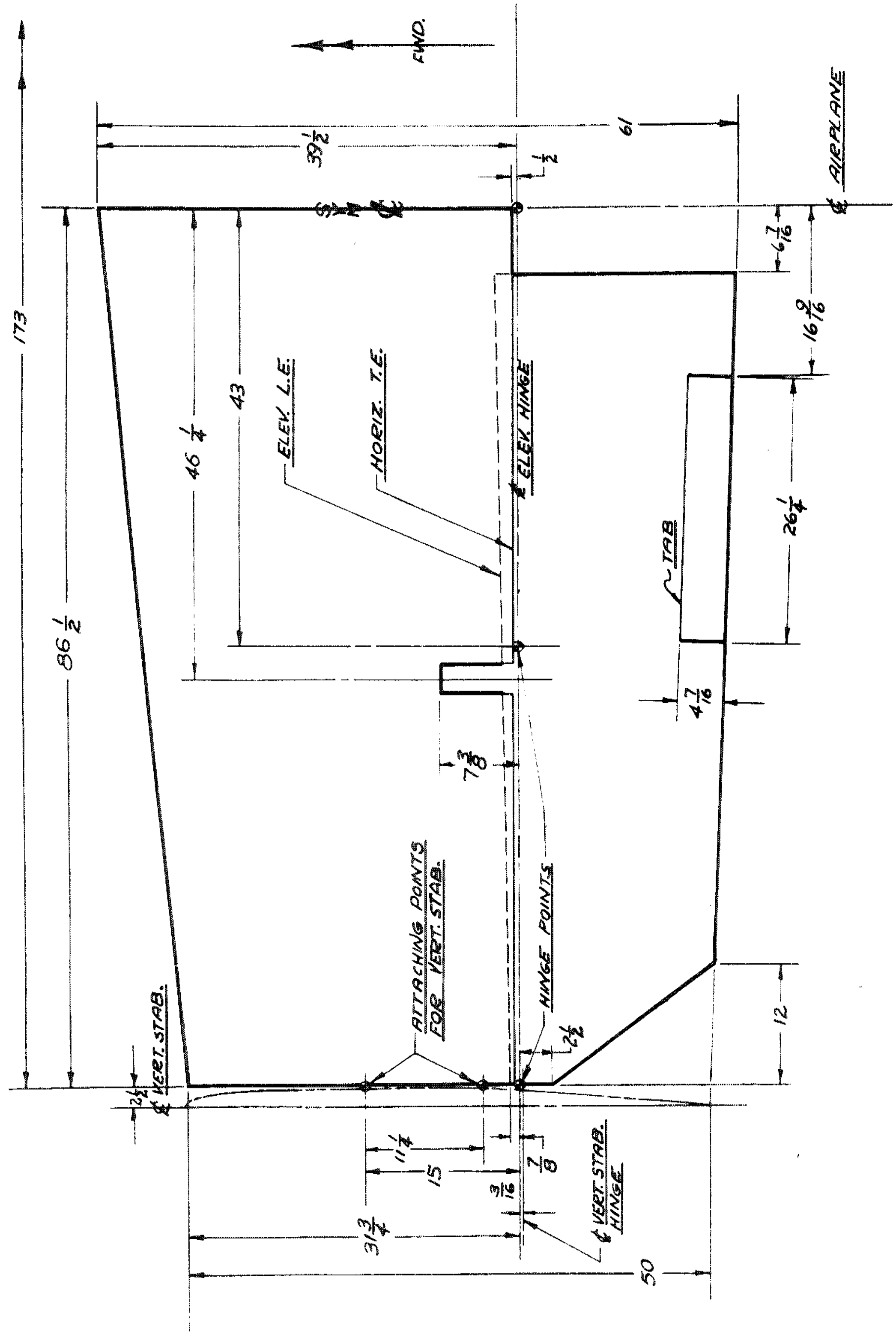
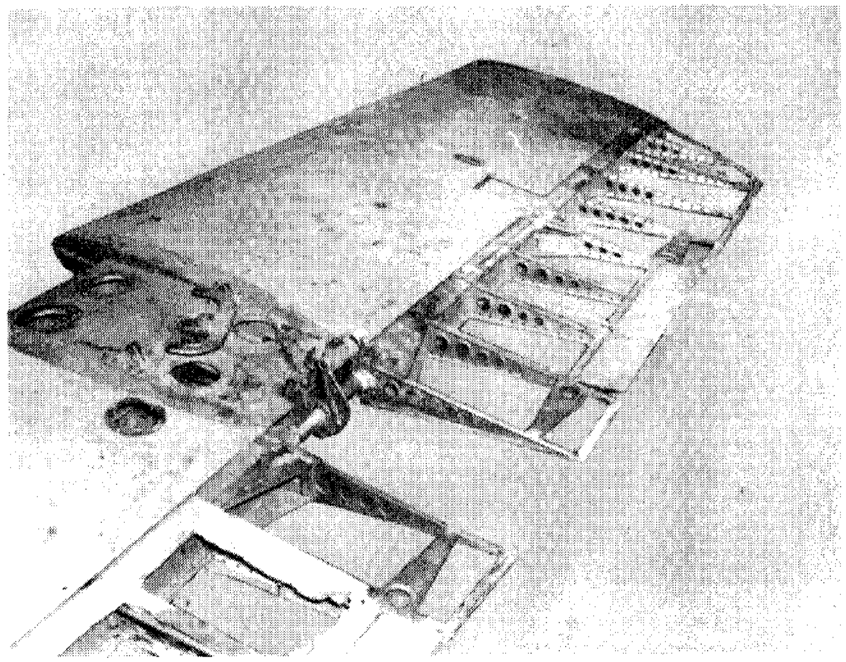
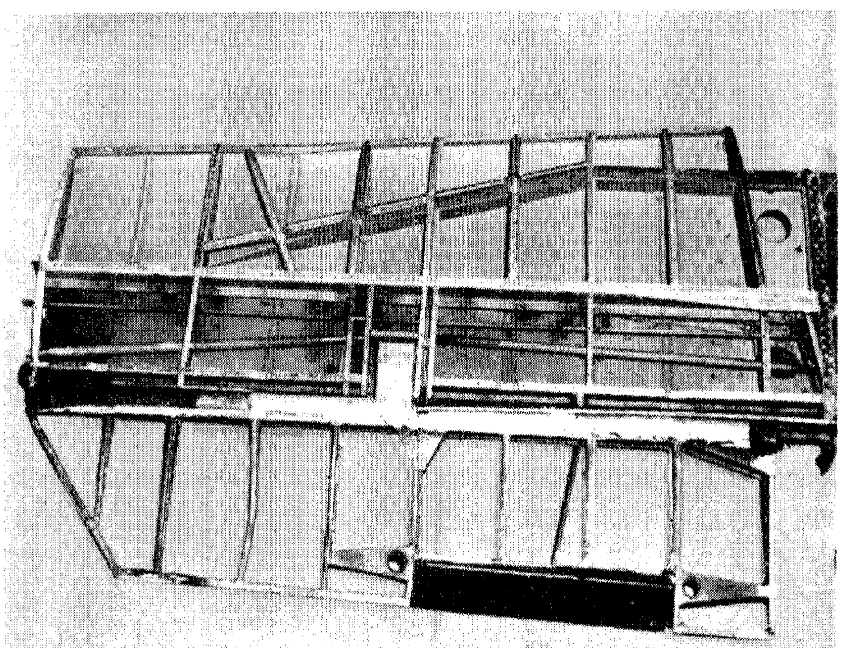


FIG. 2 HORIZONTAL SURFACE DIAGRAM FIG. 2



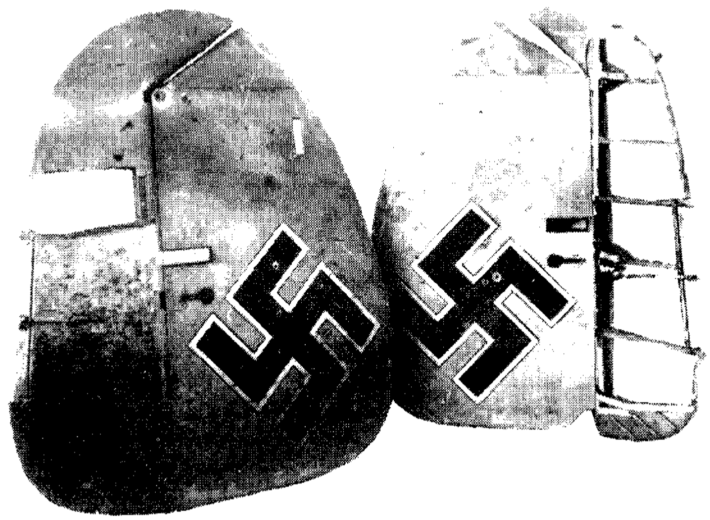
HORIZONTAL TAIL ASSEMBLY



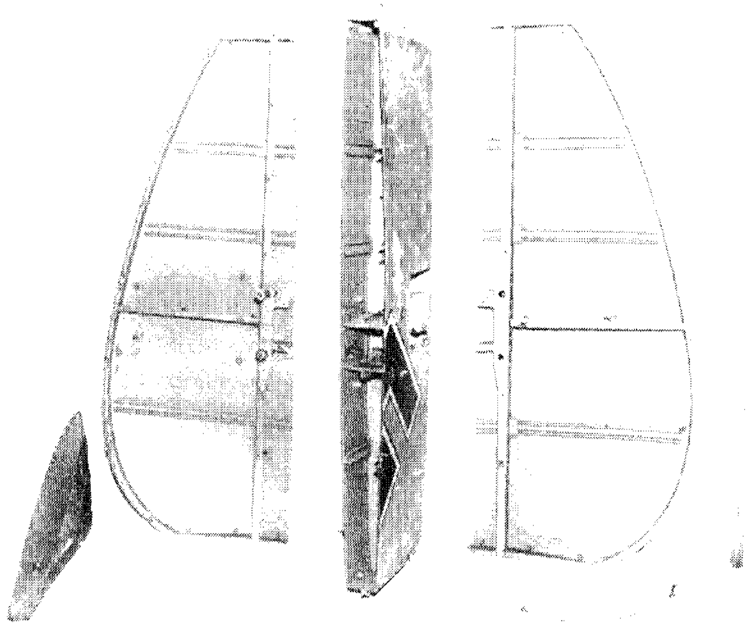
HORIZONTAL TAIL STRUCTURE

FIG. 3 HORIZONTAL TAIL FIG. 3

EMPENNAGE



VERTICAL TAIL ASSEMBLIES



VERTICAL FIN STRUCTURE

FIG. 4 VERTICAL STABILIZER FIG. 4

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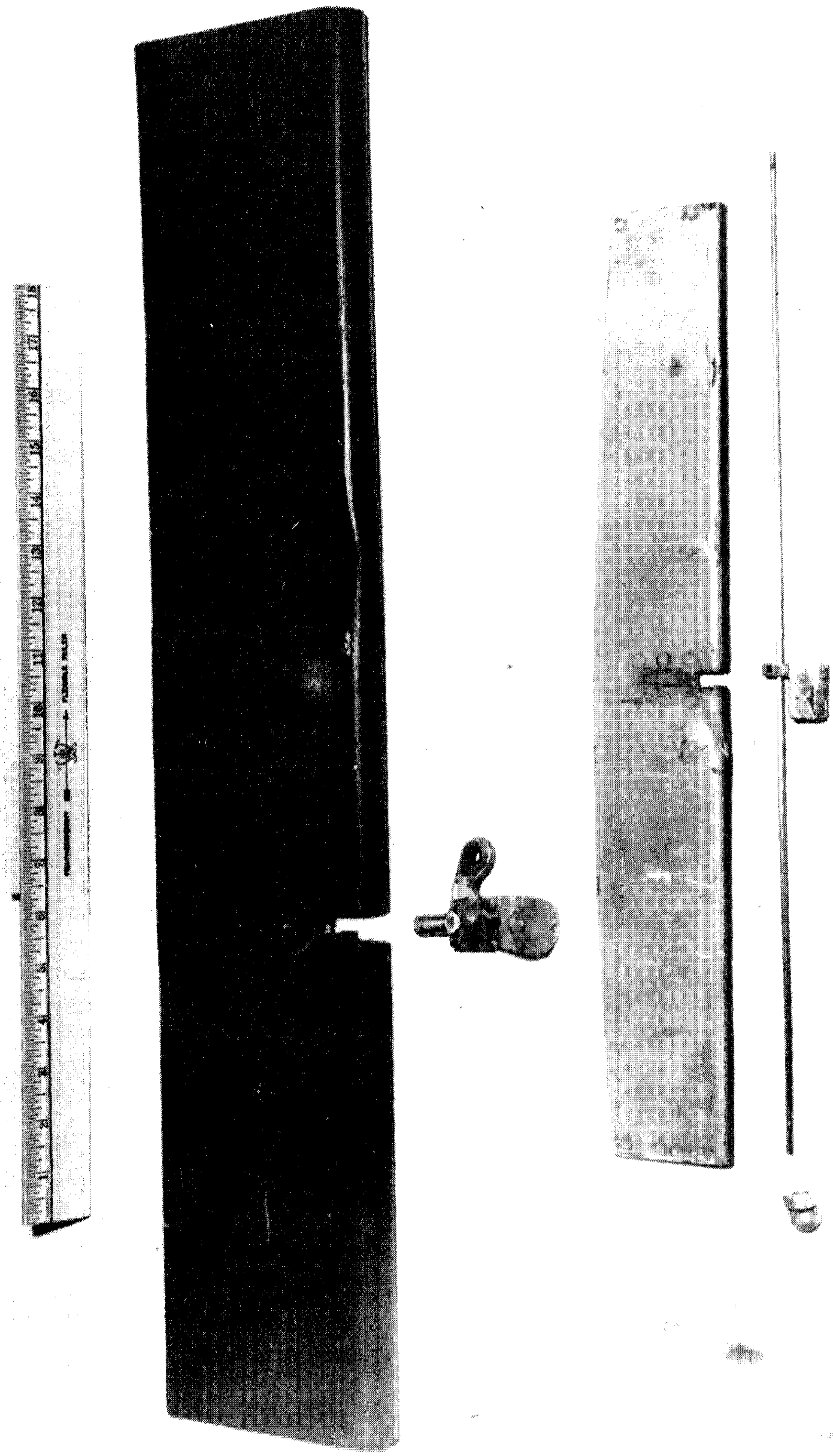

FIG. 5 TRIM TABS-HORIZONTAL & VERTICAL FIG. 5

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FUSELAGE

Chapter 4

Fuselage

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Chapter 4

FUSELAGE

The fuselage structure is a simple semi-monocoque type extending from nose to tailwheel bulkhead. The basic design is such that it is adapted to mass production. It is manufactured in symmetrical halves, joined vertically along the centerline to form the complete structure. These halves could be assembled in simple vertical jigs arranged to give the workmen free access to both exterior and interior surfaces of the half, thus tremendously accelerating production by eliminating the necessity of working in a close, cramped fuselage interior during assembly operations, permitting a larger personnel on assembly operations. It is reasonable to believe that a majority of the electrical wiring, plumbing and control mechanism within the fuselage is installed in each half while it is still in the jig, and freely accessible.

Structural Design

The fuselage structural design involves bands of aluminum-alloy sheet about 19 in. wide, with the edges of each alternate band being rolled over into a Z-section to form integral bulkhead rings. Bands adjacent to the formed sheets are simply flat sheets sprung into place, with the whole joined by flush riveting and joggled joints to form a structure free of internal bracing members. Reinforcing extends aftward from the nose section bulkhead to the rear cockpit, and hat-section stringers extend the length of the fuselage. A main-beam truss comprising a T-beam lower member and a tubular upper member connects across the fuselage. Each skin sheet extends from the lower to the

Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. L. Standley, Group Leader in Charge of Fuselage Design for the Engineering and Development Department of Vultee Aircraft, Inc.

by short stringer-sections radiating from the fitting. The skin from Sta. #187 to Sta. #222 is one piece and is stiffened by a Z-frame at Sta. #205.

Structure Aft of the Cockpits

Spliced to a Z-frame at Sta. #222 is a skin panel terminating with a Z-section and joggle at Sta. #240. A series of skin and integral frame combinations extend aft from Sta. #240. Every alternate skin panel has a joggle and a 1 in. high Z-flange rolled on each end. These sections form half the fuselage, and splice at top and bottom. Connecting these sections are flat skin panels wrapped around and riveted to the "Z" ends. The joggles are long enough to allow ample shop tolerances, and the space between skin and joggle ends is filled in smooth with a substance similar to glaziers putty.

Longitudinal stringer spacing is from 13 to 16 in. on the sides, and 8 to 10 in. on the bottom. Very few stringers extend forward of Sta. #187.

In some places where stringers change section, they stop at one side of a frame and begin on the other without tie-bars or doublers; thus depending upon the skin to carry the load. Also, at numerous places light equipment is attached directly to the skin without local support.

Nearly all of the stringers are inverted hat-sections of uniform size, except those at top and bottom. These are wider to provide for two rivet rows at the skin butt-joint on the centerline. All stringer cutouts in the Z-frames are oblong holes with slightly upset edges. The frame sections are connected at top and bottom with short channel-shape splice plates.

Tail Wheel Bulkhead

The tail wheel and horizontal stabilizer attach to a canted frame between Sta's. #419 and #449. Additional stringers are used aft of Sta. #401 to carry landing and flying loads.

A removable fairing attaches aft of canted frame to provide access to the tail-wheel strut fittings. The tail cone extending from Sta. #449 to Sta. #481 is detachable, and can be released from the cockpit.

Access Openings

Cutouts through the skin for access to fuselage equipment are reinforced with channel or hat-section doublers. Doors are attached with either screws and nut-plates, or self-locking screw-type fasteners.

There are very few skin load-concentrations which require doublers, and most of these have doublers with rounded edges placed on the outside of the skin, to eliminate joggling of interior parts. Doublers not in the airstream have slightly rolled edges for stiffness. Skin rivets throughout the entire fuselage are uniform, spaced about 1-1/8 in. on center, and those in the air- stream are counter-punched flush.

The floors throughout the cockpits are flat sheets attached to light cross-members and secured with screws.

FUSELAGE

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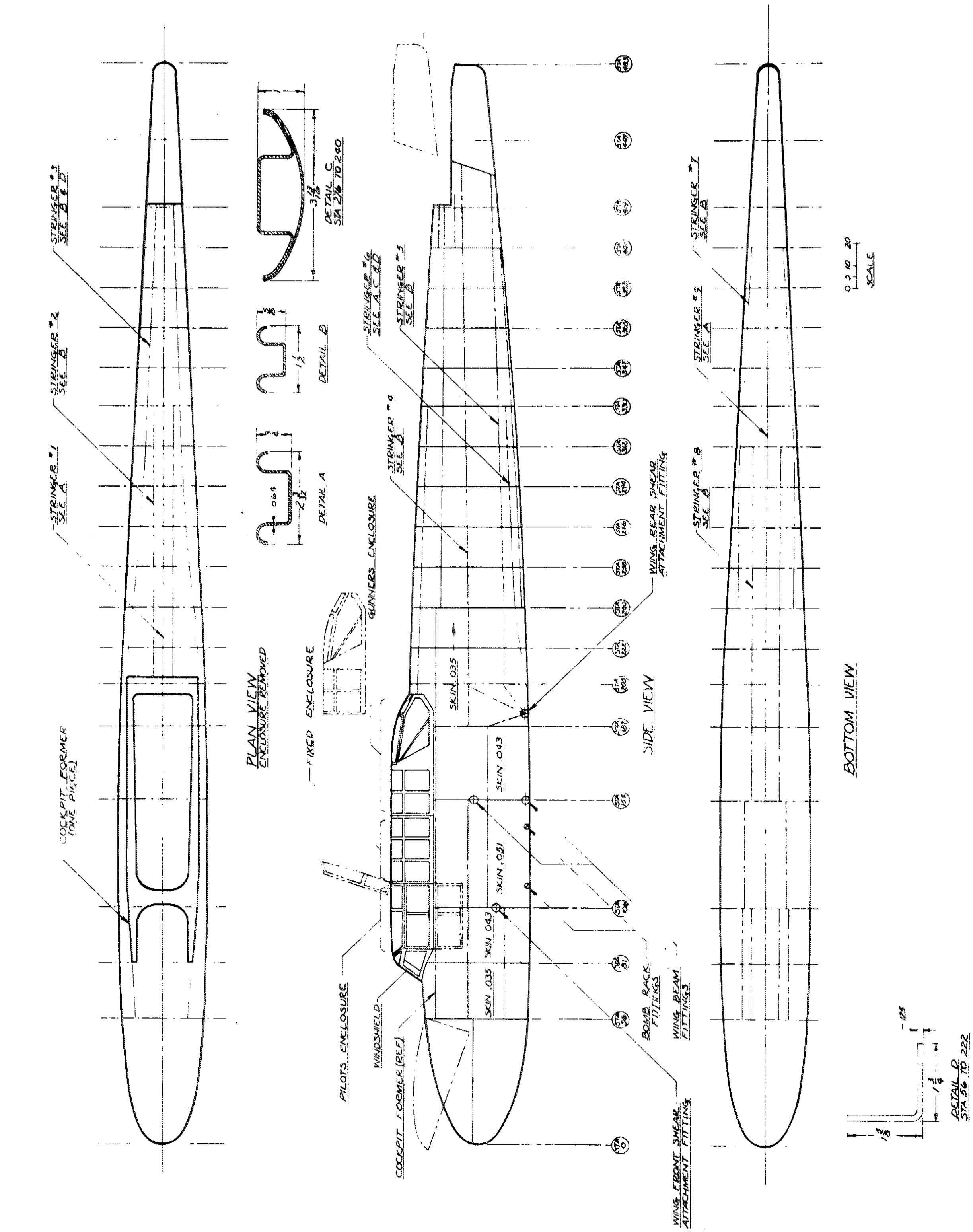

FIG. 1 FUSELAGE MASTER DIAGRAM FIG. 1

FUSELAGE

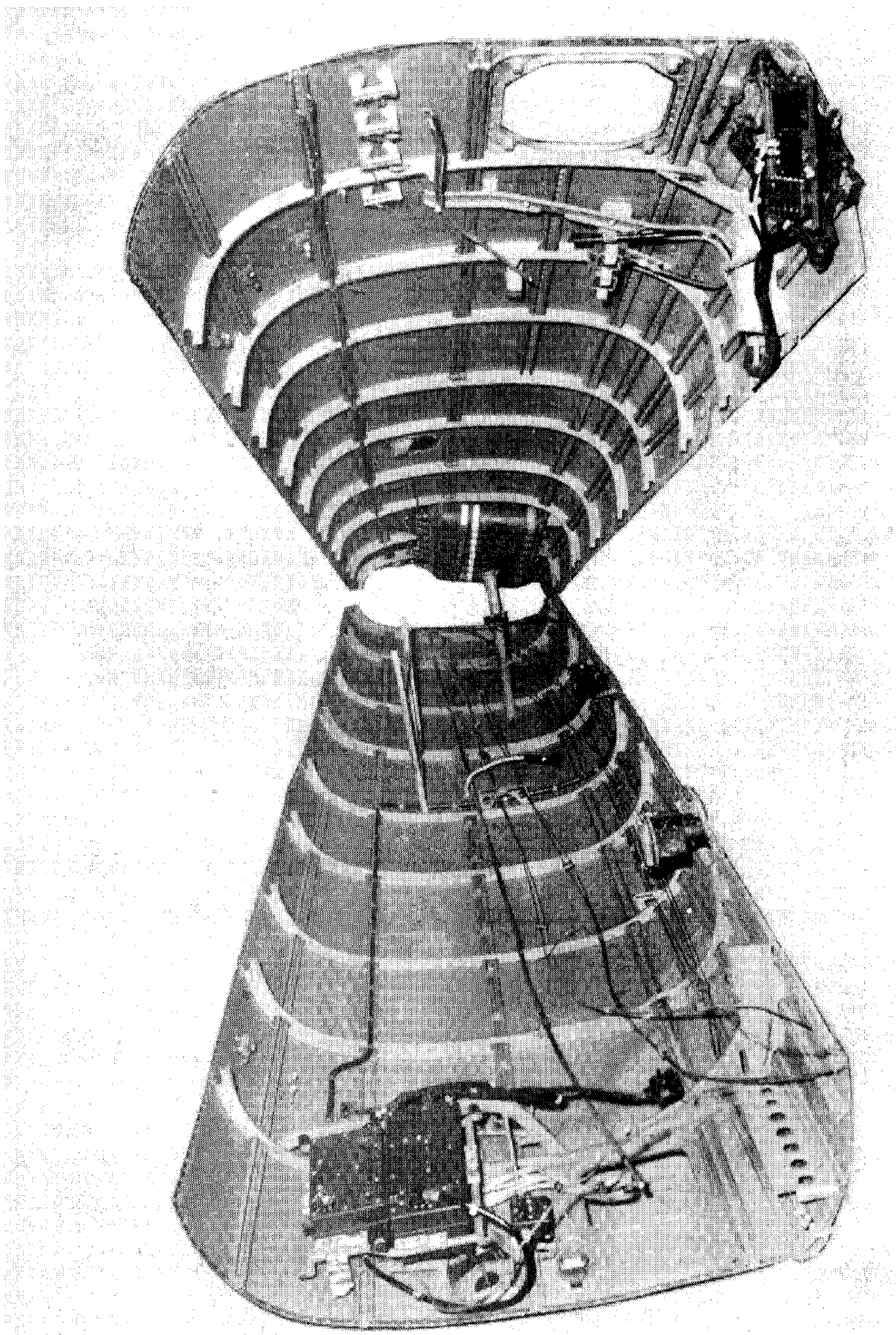

FIG. 2 INTERIOR OF MONOCOQUE SECTION FIG. 2

FUSELAGE

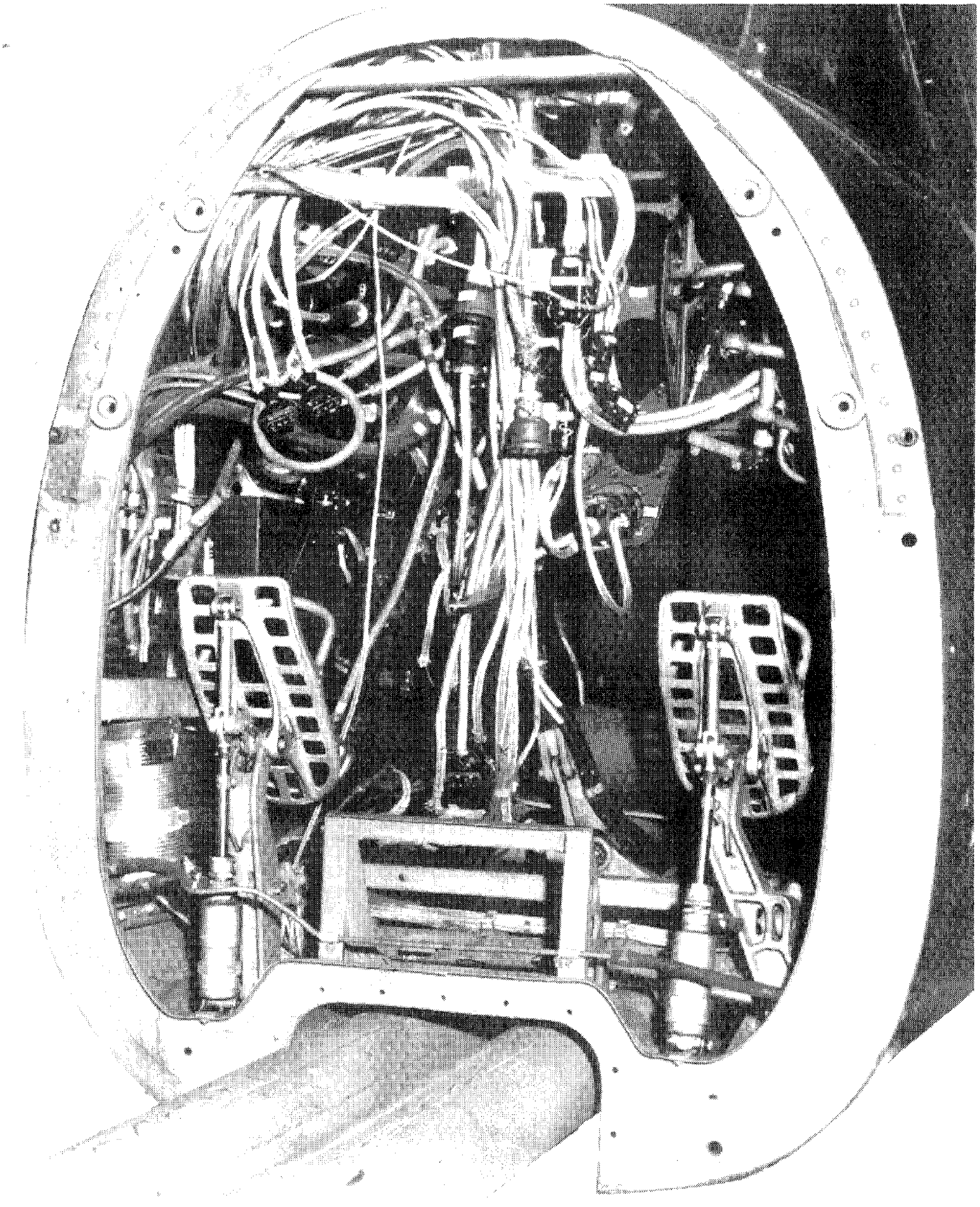

FIG. 3 FUSELAGE FORWARD BULKHEAD FIG. 3

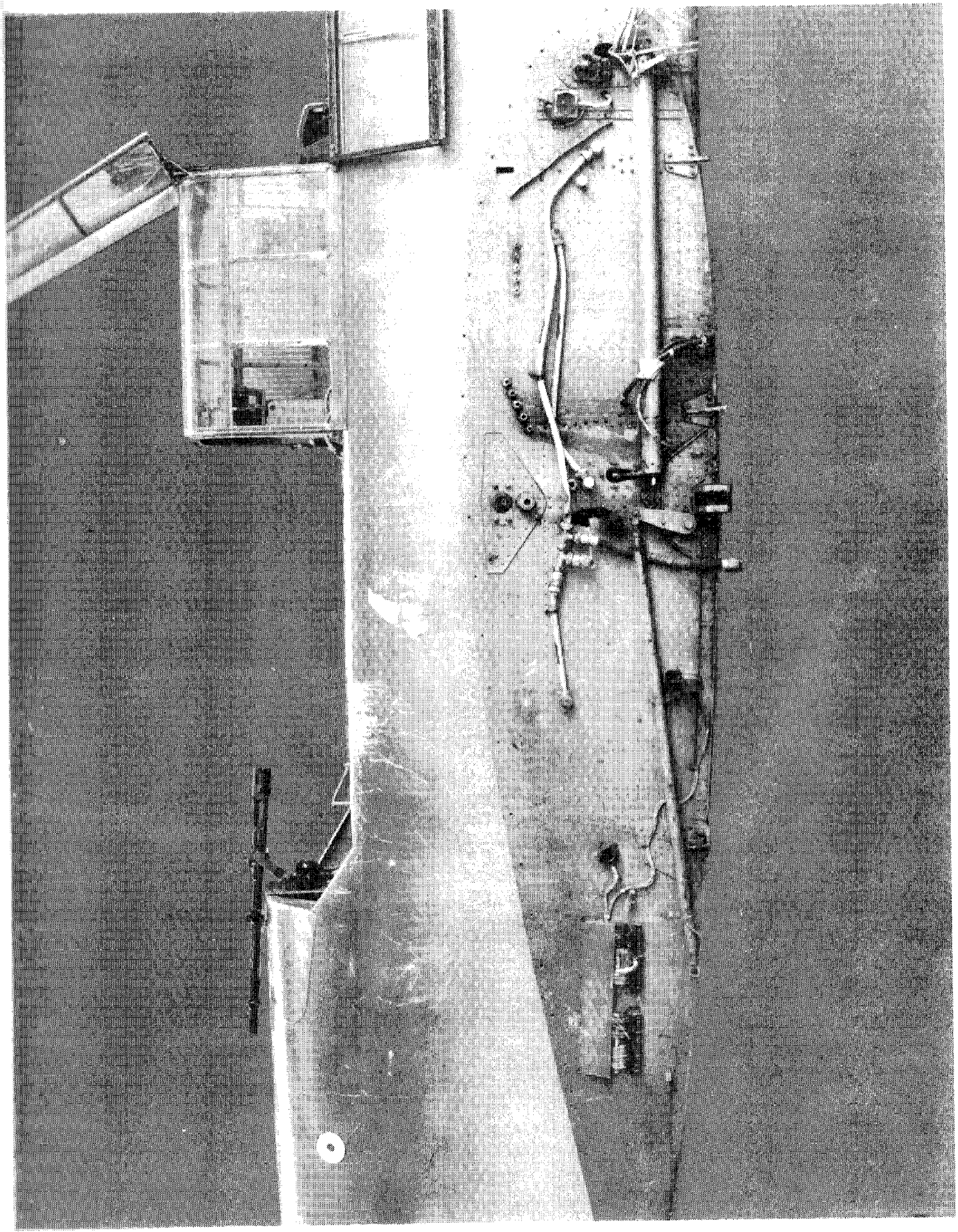

FIG. 4 WING TO FUSELAGE JUNCTION FIG. 4

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LANDING GEAR

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Landing Gear

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LANDING GEAR

A hydraulically-operated, fully-retractable main landing gear is used, with the landing gear "legs" being folded aftward and up into retracted position within the engine nacelle lower fairings, and completely inclosed by automatically operated doors, extending the length of the nacelle fairings. Actuation is accomplished by an hydraulic cylinder connecting to the center of a knee-strut, with the result that compression of the cylinder lifts strut and wheel into retracted position.

Hydraulic Actuation

The hydraulic system uses a maximum working pressure of approximately 2,000 lbs/sq.in., and the landing gear mechanism is simplified by automatic locks, for extended and retracted positions, built within the actuating cylinders. Thus, each landing gear installation comprises but a pivoted cantilever shock absorber strut and wheel assembly, a knee-strut, and an hydraulic actuating cylinder.

Emergency Air Pressure Actuation

A compressed air system provides for emergency actuating of the landing gear, with air stored in small cylinders at approximately 2,200 lbs/sq.in. pressure.

Wheels and Brakes

Manually-operated dual-band hydraulic wheel brakes are used. Standard tire and wheel assemblies are used, with 875 x 320 metric tires being fitted to the main landing gear, and a 465 x 165 tire used on the tail wheel.

LANDING GEAR

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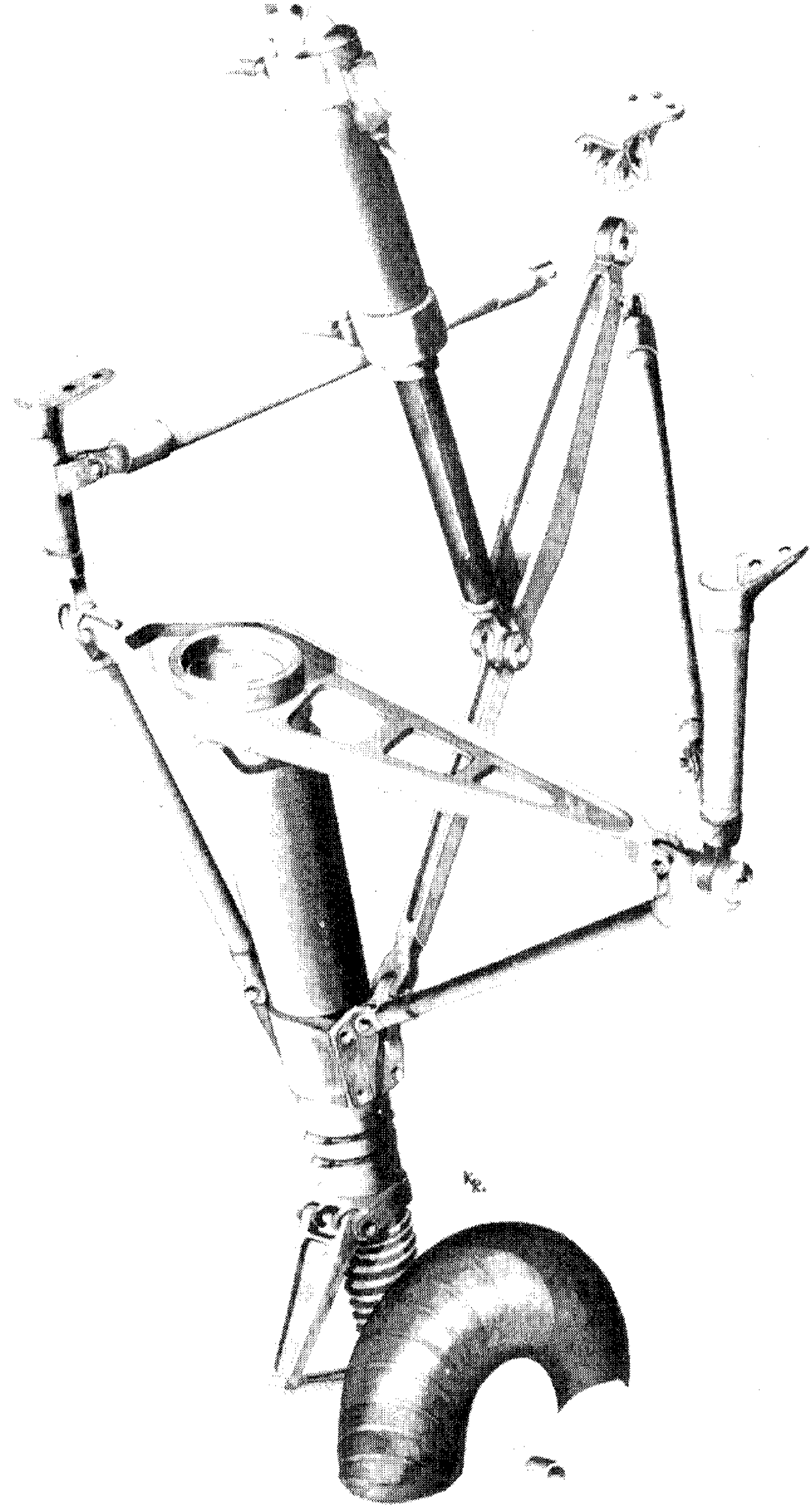

FIG. 1 LANDING GEAR ASSEMBLY FIG. 1

LANDING GEAR

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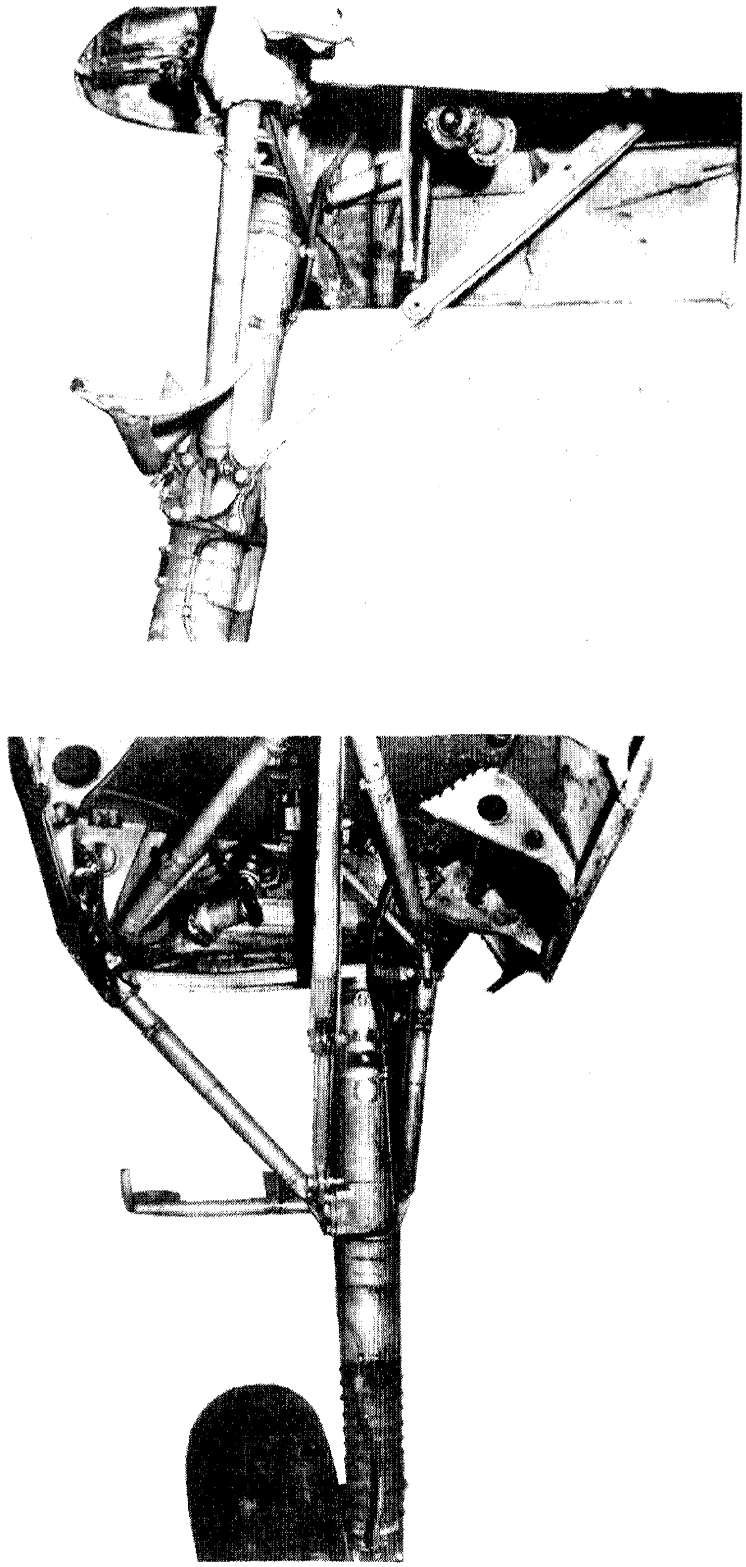

MAIN LANDING GEAR FIG. 2

LANDING GEAR

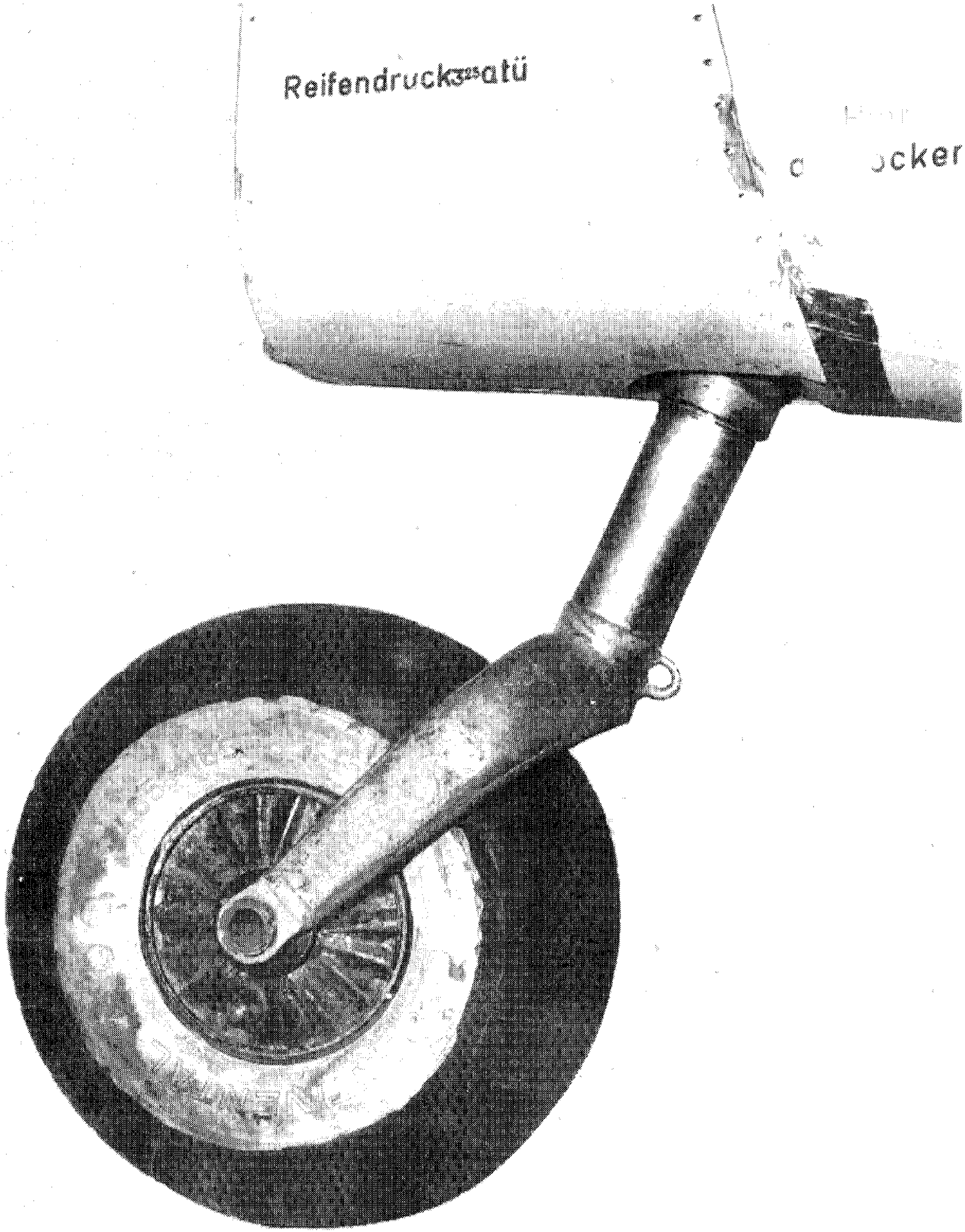

FIG. 3 TAIL WHEEL INSTALLATION FIG. 3

LANDING GEAR

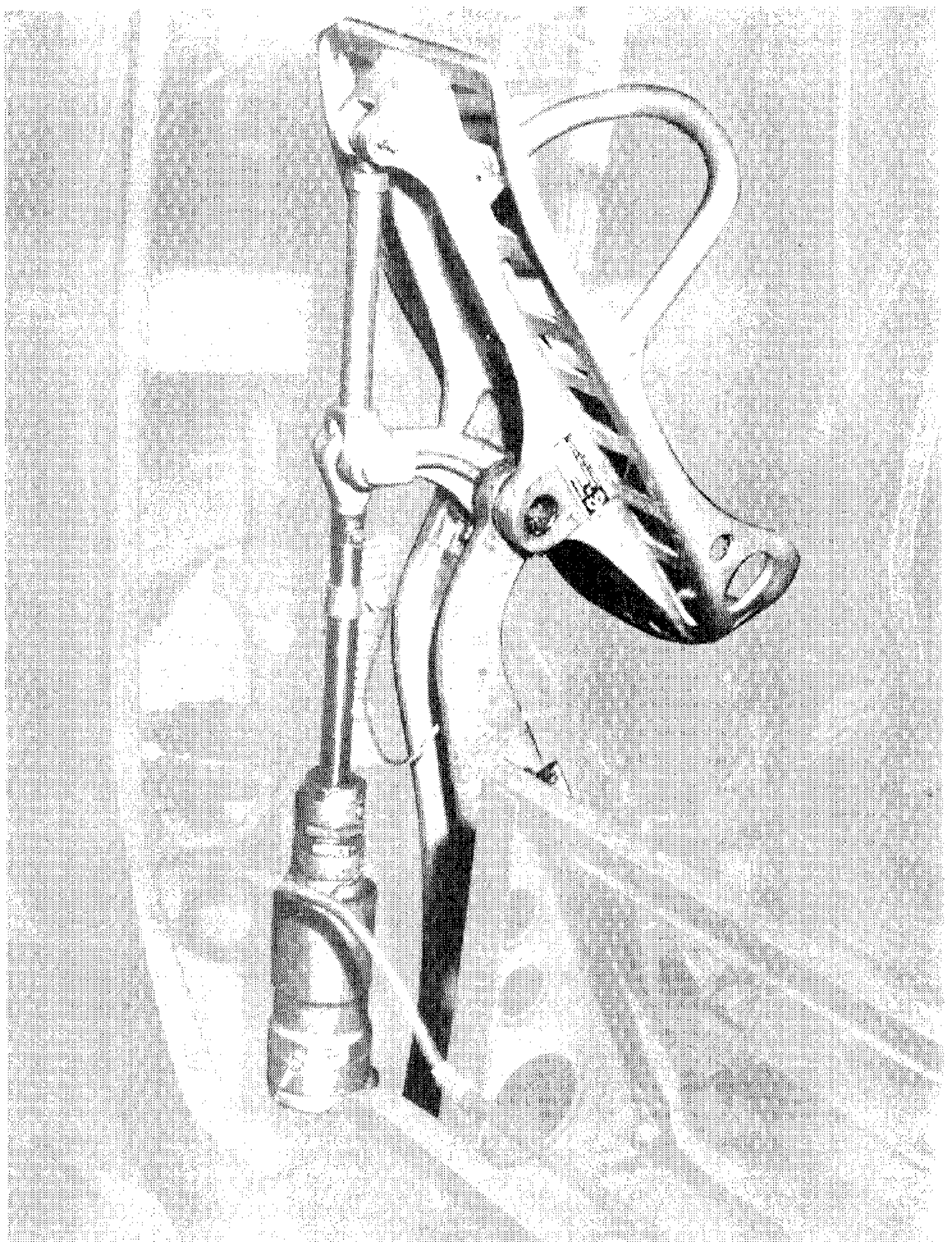

FIG. 4 BRAKE MASTER CYLINDER INSTALLATION FIG. 4

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ENGINE

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Chapter 1

ENGINE

General Description

The Daimler-Benz DB-601A engines used in the Me110 are liquied-cooled 12-cylinder, 60 deg. inverted-Vee type; with the cylinders arranged in two banks of six. The major features of this engine are use of fuel injection instead of conventional carburetion, and a fluid-drive, variable-speed supercharger. This engine is apparently manufactured by both Daimler-Benz, and Mercedes-Benz, as both firms are mentioned in contemporary literature on the subject.

For a complete discussion of the DB-601A engine refer to "Mercedes-Benz DB-601A Aircraft Engine" by Raymond W. Young, appearing on pages 409 through 431 of October, 1941 issue of the "S.A.E. Journal".

Variable-Speed Supercharger

The variable-speed centrifugal supercharger is a conventional 10-1/4 in. dia. machined aluminum impeller, running in a vaneless diffuser, and driven from the engine through a hydraulic coupling very similar to the fluid-drive of some American automobiles. This coupling is said to permit automatic variation of the drive-ratio to maintain maximum supercharger efficiency at altitudes between sea level (7.5:1 ratio) and the critical (10.4:1 ratio).

The supercharger drive-coupling comprises a balanced pair of driven turbine-wheels, located at each side of a single two-faced driving turbine-wheel. The latter is actuated from the crankshaft accessory-drive gear-train by a shaft passing through a quill-shaft in one of the driven-wheels. Engine oil is the

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by R. Soucek, Experimental Engineer, and H. S. Fowler Jr. Power Plant Analysis Engineer for the Engineering and Development Dep. of Vultee Aircraft, Inc.

hydraulic medium, and varying the amount of oil supplied the coupling is the means of varying the supercharger drive-ratio.

Fuel Injection

Fuel is supplied directly to the combustion chambers through individual injectors served by a Bosch 12-cylinder injection pump, using equipment similar to that of Diesel engines, but lighter and smaller. The injection pump is fitted between the cylinder blocks, provided with manual control, and automatic correction for manifold pressure, manifold temperature, and altitude.

Fuel found in the tanks of captured airplanes equipped with the DB-601A engine has been 92 octane C. F. R., although the engine is apparently designed for 87 octane. A small quantity of fuel found in the strainers of the airplane examined at Vultee was analyzed by the Shell Oil Company laboratories, and found to rate about 90 octane C. F. R.

Construction Features

The main bearing caps are secured with threaded collars having a splined O.D., instead of the usual six points of a hexagon nut. This construction permits use of nuts in confined locations.

Four valves are used in each cylinder, with the two exhaust valves using sodium-filled stems.

A novel means is employed to attach the cylinders to the crankcase. Each cylinder skirt is externally threaded below its flange, and this threaded sleeve projects through the crankcase deck to be held by a large ring nut having gear teeth on its O.D. The nut is tightened by a pinion-wrench piloting in the crankcase deck.

The induction system of the DB601A includes an automatic, atmospheric-pressure controlled throttle. This unit, mounted on the accessory section, operates a butterfly valve in the manifold between supercharger impeller and manual throttle, to maintain altitude-corrected manifold-pressure supply at the manual-throttle.

A chronometric mechanism adjacent to the propeller-control motor limits take-off power to one minute. This unit is brought into action when the throttle control is moved past the normal full-throttle stop to reach take-off power manifold pressure. Sixty seconds later, the action of the limiter unit returns the throttle to normal maximum position and increases the propeller pitch to reduce the maximum engine RPM from 2500 to 2400.

Power Plant Installation

A simple straight-forward power plant design is used for the Messerschmitt Me110, comprising an engine mount formed from four sturdy magnesium forgings, each attaching to a fitting at the wing main beam. The complete power plant installation is readily removable from the airplane by disconnecting a few lines and control rods. In fact, the complete installation is undoubtedly assembled as a unit, and then quickly connected to the wing during final assembly operations.

All control rods and bellcranks are obviously standard parts, identical with those used in other German military aircraft, and of a type originally developed by Junkers, wherein serrated faces on bellcrank levers are clamped between flanges on a torque rod or bracket bushing to permit adjusting the lever or levers to the proper angle for a particular application. Piping, end fittings, clamps, many brackets, and the like are also standard parts. This practice of standardizing all engine installation parts is greatly assisted by the fact that practically all German military airplanes are equipped with either a Daimler-Benz, or a Junkers Jumo engine, and both these have approximately the same overall dimensions, connections and control locations, permitting the use of identical mounts for either engine.

Engine Mount

Each engine mount essentially comprises two cantilever beam engine-bearers, and two compression struts. Each cantilever beam is attached to the engine through two massive rubber blocks, one at the forward-end and above the engine CG, and another approximately midway of the beam and aft of the CG. Vertical loads are resisted by compression members attached to the cantilever beams at points slightly forward of the rear shock-absorber. Engine mount beams and struts are magnesium-alloy forgings, and are attached by steel fittings and self-aligning bushings to the main beam and the landing gear support structure. Side loads are resisted by a loose-joint yoke arrangement connecting between the inboard compression strut and the airplane structure.

Cowling

The engine cowling essentially comprises light-metal alloy sheet secured at the aft edge by a rolled extrusion, and attached along the other edges by quarter-turn snap-lock fasteners. A hinged door is provided in each side of the cowling for spark plug access. Vents are provided at the cowling leading-edge to provide air blasts around the base of the exhaust stacks, and through the accessory compartment.

Accessories

The magneto is a dual type of excellent design and workmanship. The high tension cables are 18-strand reverse-wound copper, with three laminated coverings comprising rubber, cotton braid and flexible lacquer. The wire braid around the harness and cables is only partially effective as radio shielding and is not waterproof. The spark plugs weigh less than comparable American plugs due to aluminum shield-barrels and ceramic insulation. Refer to the Appendices for complete information on magneto, ignition wiring, and spark plugs.

Engine accessories include:

(I) Starter - electric inertia, with provisions for emergency hand cranking by a shaft extending to the side cowling.

(II) Generator - 24 volt, 1500 watt.

(III) Hydraulic pump (or optionally, vacuum pump) - swashplate driven, six-plunger type.

(IV) Coolant pump - centrifugal.

(V) Oil pumps - pressure pump is gravity-feed through wire wound filter. A scavenger pump is located in the aft end of each camshaft cover.

(VI) De-aerator - Mounted underneath the engine and aft of the injection pump unit.

The engine intake air is drawn through the leading edge of the wing by a right-angle scoop having nine turning vanes, and connecting with a six-inch diameter duct leading to the supercharger intake. Intake air preheat is not provided, as this is probably not necessary for a cylinder-head fuel injection engine.

Exhaust System

The exhaust system consists of individual stacks attached to three-stud exhaust-port flanges. These stacks face upward on the outboard side of the nacelle, to prevent the hot gases entering the coolant radiator, and downward on the inboard side, to avoid exhaust glare interfering with the pilot's view. The stacks are heavy-gauge steel, formed and welded to the desired shape. No attempt is made to shield the exhaust flames from the view of ground observers.

Engine Controls and Instruments

Engine controls are grouped in pairs on a quadrant at the pilot's left, and include throttle, supercharger, and mixture. Control creep is prevented by leather friction washers in the control quadrant. The levers are long, and should provide sensitive, easily-operated engine control.

The engine primer pump is located at the pilot's right, and delivers fuel from a special two-quart tank to the intake manifold. A plate on the tank specifies priming-fuel mixtures as being: "Summer - 90% gasoline, 10% oil; and "Winter - 50% gasoline, 40% ether, 10% oil".

Engine instruments on the pilot's panel include:

(I) Manifold pressure gauges.

(II) Electric tachometers. These consist of AC voltmeters calibrated in revolutions per minute, and actuated by AC generators driven at 1/2 engine speed. A clue toward the engine operating limits is given by marks on the face of the tachometers at 2200, 2300 and 2400, probably corresponding to normal cruising, normal maximum, and take-off rpm.

(III) Coolant gauges.

Openings are provided in the engine cowling for additional engine instruments. These were not installed when the Me110 reached Vultee, but were probably oil pressure, oil temperature, and fuel pressure indicators.

Engine Characteristics Compared with Allison and Rolls-Royce

	Daimler-Benz	Allison	Rolls-Royce
Model	DB-601A	V-1710C	Merlin X
Number of cylinders	12	12	12
Arrangement	Inverted Vee	Upright Vee	Upright Vee
Bore (inches)	5.7	5.5	5.4
Stroke (inches)	6.3	6.0	6.0
Piston displacement (cubic inches)	2070	1710	1647
Military rating (horsepower)	1000	1090	1025
Military rating (revolutions per minute)	2400	3000	3000
Military rating altitude (feet)	14,800	13,200	17,750 (high blower)
Estimated horsepower 15,000 Ft.	990	1020	1150
Take-off horsepower	1150	1040	1045
Take-off RPM	2500	3000	2850
BMEP (military rating)	158	168	164
BMEP (take-off)	167	160	176

(cont'd.)	Daimler-Benz	Allison	Rolls-Royce
Compression ratio	6.8	6.65	---
Take-off HP/cu. in. displacement per minute.	.000111	.000101	.000111
Dry weight (pounds)	1367	1325	1394
Unit weight (lbs/to HP)	1.19	1.27	1.33
Height (inches)	40.5	42.1	41.1
Width (inches)	29.1	30.6	29.8
Overall length (inches).	84.0	94.5	75.1

ENGINE

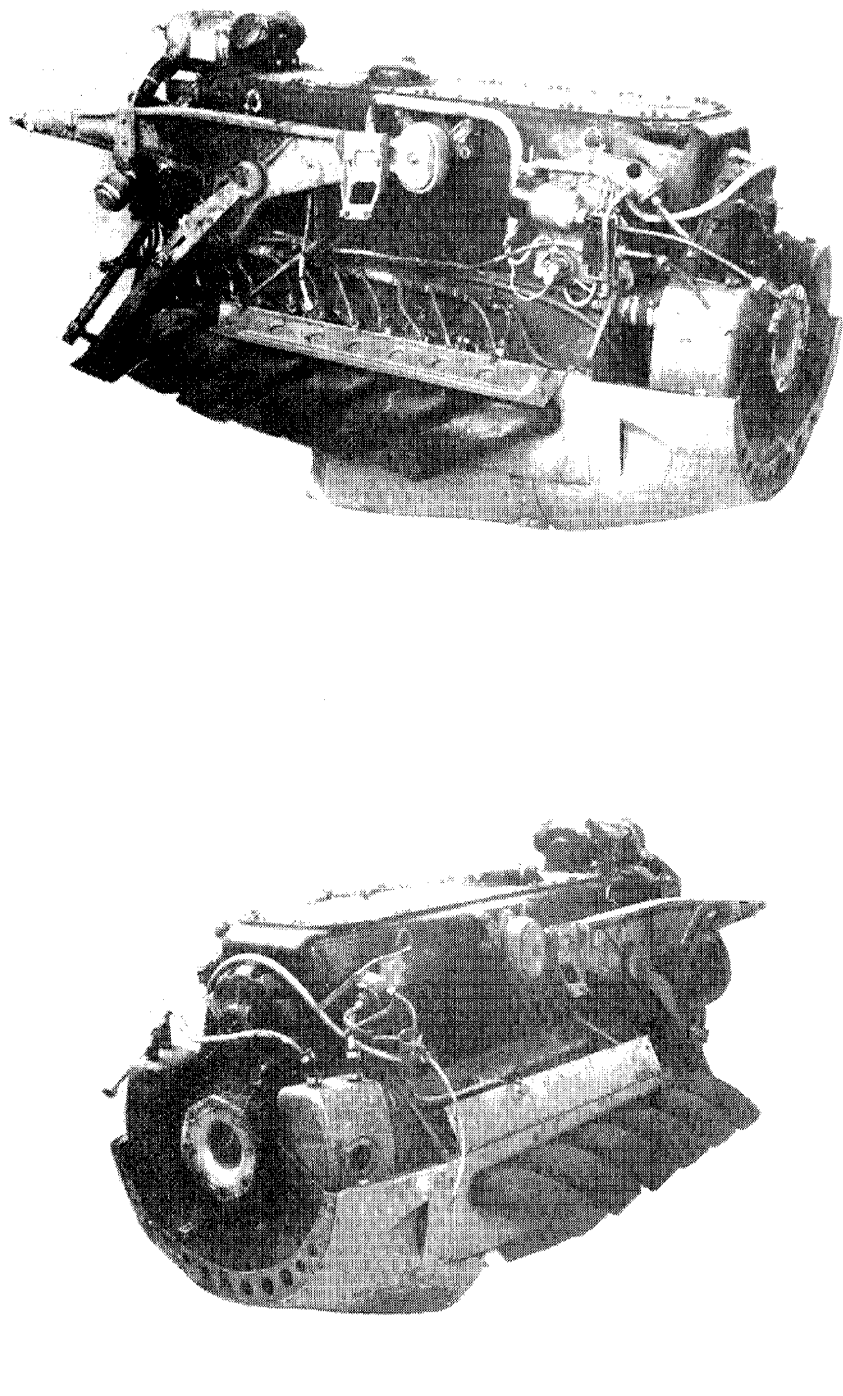

Fig. 1 DAIMLER-BENZ DB 601 ENGINE Fig. 1

POWER PLANT

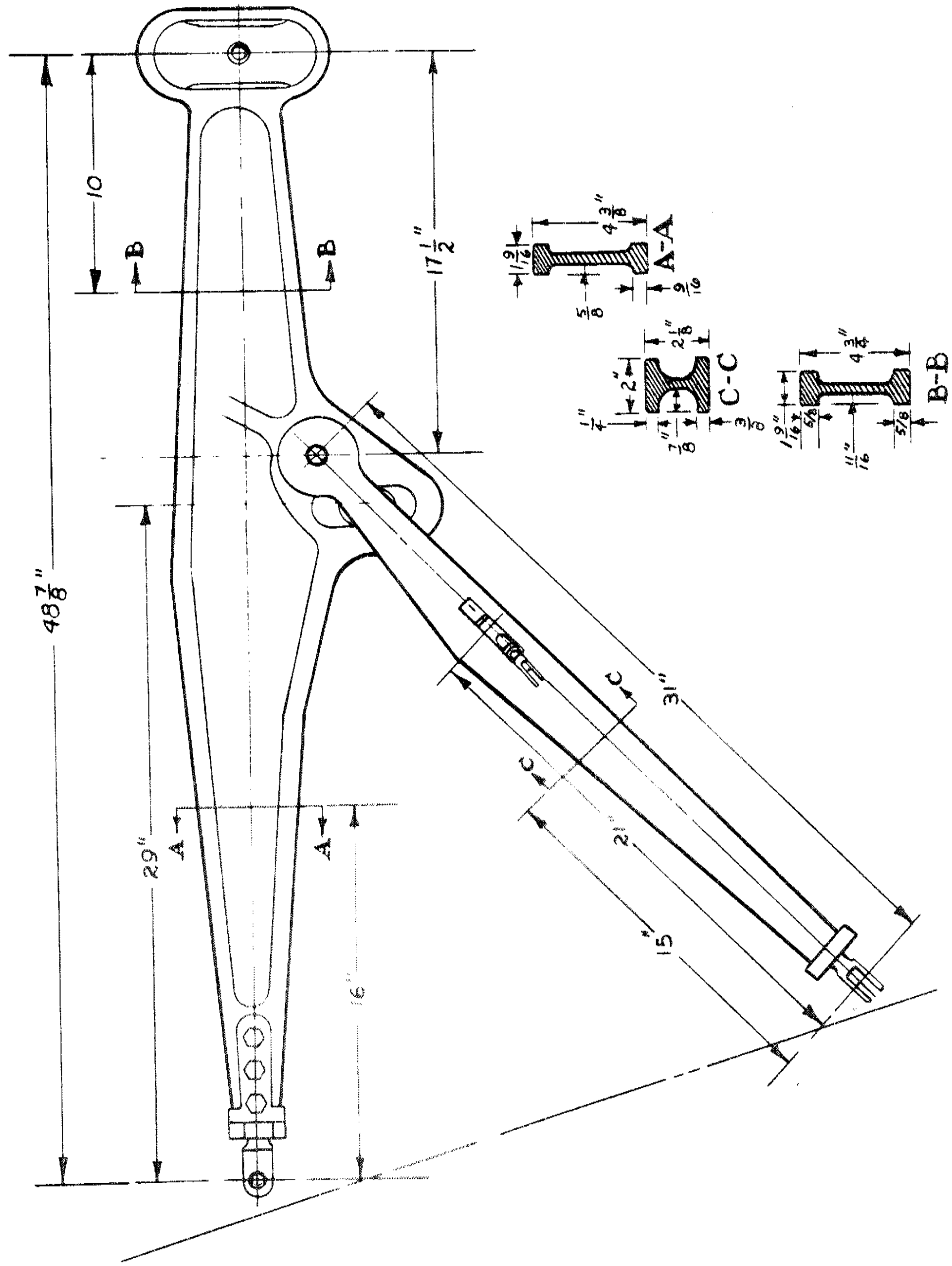

FIG. 2 ENGINE MOUNT MASTER DIAGRAM FIG. 2

ENGINE

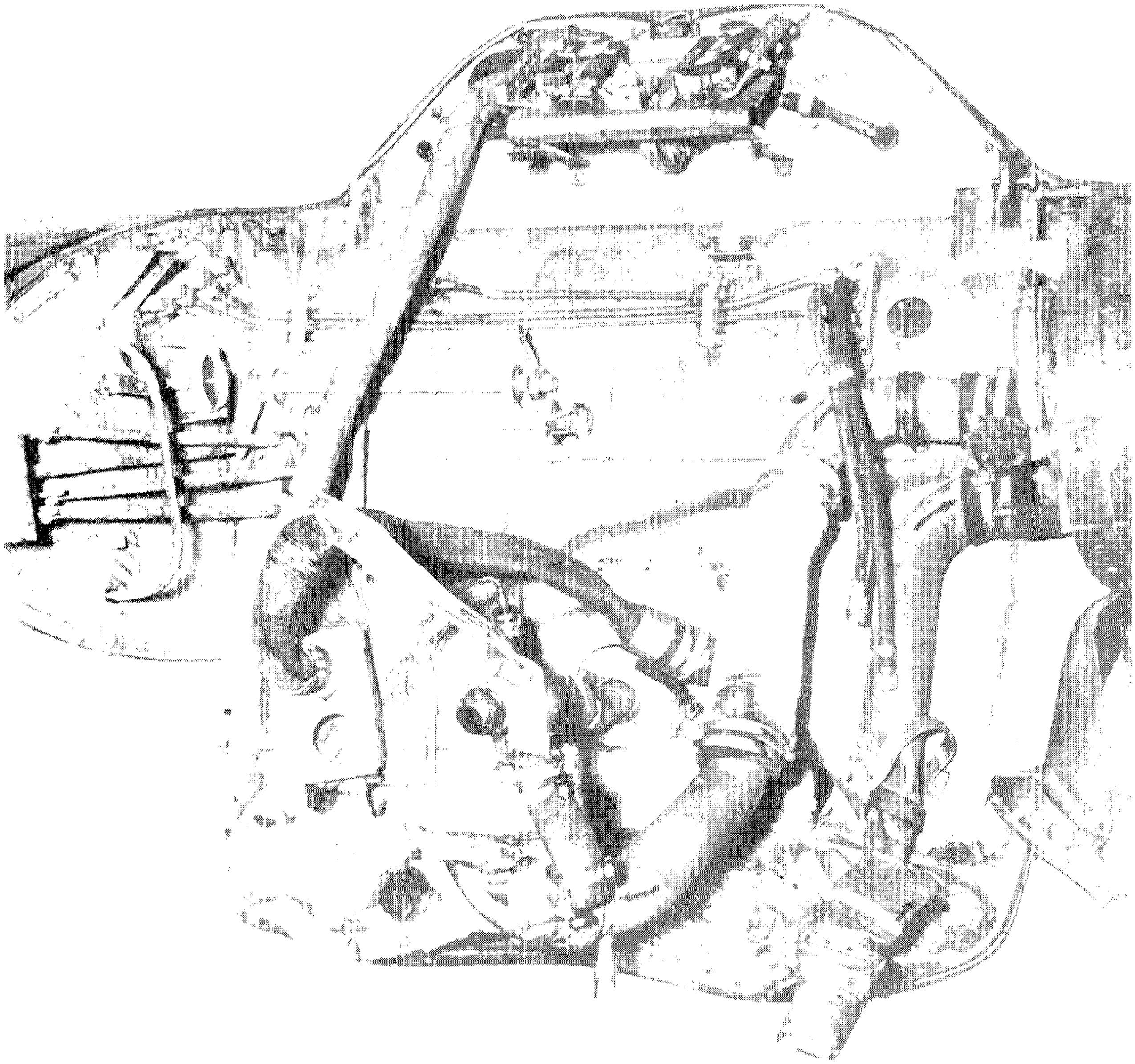

FIG.3 FIREWALL-LEFT SIDE ENGINE FIG.3

Chapter 2
PROPELLER

SECTION II

Chapter 2

PROPELLER

General Description

Each engine drives a three-blade, electrically controllable propeller of 11 ft. 3 in. diameter. These propellers are not a constant-speed type, and are constructed quite differently from our Curtiss electric propeller, as each blade is provided with a worm sector and pinion near the blade root, with a spur gear on each pinion shaft meshing with a large ring-gear concentric with, and driven by, a planetary gear train mounted directly behind the propeller, on the propeller support-shaft. The planetary gear train, in turn, is actuated by a propeller-control electric motor mounted on the engine crankcase, and driving through a short flexible shaft.

Connection of propeller support-shaft to engine propeller-shaft is through a flange coupling having mating flange faces deeply serrated to relieve the clamping bolts from shear load. An automatic timing device prevents engine operation at take-off power for more than one minute at a time.

Propeller Blades

The blades are forged aluminum alloy, and have hollow shanks machined with three large, square-cut threads arranged to mate with a cylinder supported on roller bearings within the hub. A gear sector on the O.D. of this cylinder is driven by the pitch control worm.

Propeller cuffs are not used, and the power section of the blade is carried to the hub. This construction was discontinued in this country several years ago due to the abrupt section change causing excessive stresses in the shank.

Editor's Note: The technical data for this portion of the Messerschmitt Analysis was contributed by R. Soucek, Experimental Engineer, H. S. Fowler Jr. Power Plant Analysis Engineer and Neil McGaffey, Mechanical Engineer for the Engineering and Development Dept. of Vultee Aircraft, Inc.

Pitch Control Mechanism

The mechanism for controlling the pitch provides for selective settings through a range from low pitch to full-feathered position. Basically, it is a means for mechanically controlling the relative position of elements rotating on the same axis.

Driving gear A (Refer to Fig. 2), rotating at propeller speed, rotates planet gears B, which in turn rotates driven gear E through idler gear C and planet gears D. Gears A and E are 84-tooth while gear C is 87-tooth.

Since $\frac{AC}{CE} = 1$, gear A and gear E will rotate in unison so long as the axial points of gear D and B remain constant.

Since gear A and D are rotating at propeller speed, planet gear G, being fixed to the propeller, will be prevented from rotating about its own axis by gear F (which is integral with gear E) maintaining a constant pitch of blade K through worm and gear in housing J.

To alter pitch of blade K, electrically-driven gear I rotates gear H which carries planet-gears B. As gear A has 84 teeth and gear C has 87 teeth, one revolution of gear H will advance gear C three teeth forward of gear A; gear B being common to both.

Gear C driving through gear D, will then move gear E relative to gear A an equal amount; and, gear F being integral with gear D, will rotate gear G about its axis, altering pitch of blades K through worm and gear at propeller shank.

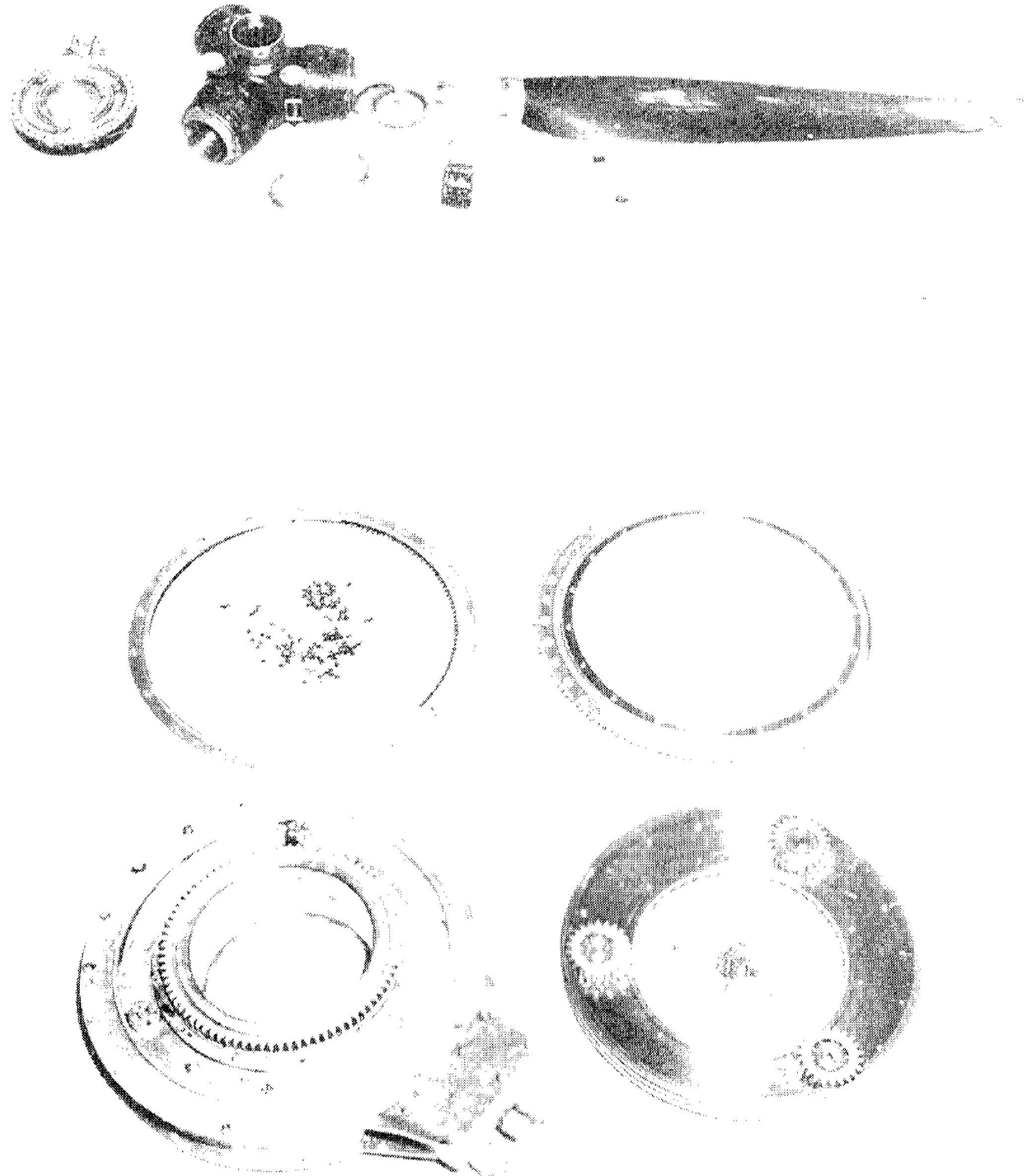

Fig. 1 PROPELLER & PITCH MECHANISM Fig. 1

PROPELLER

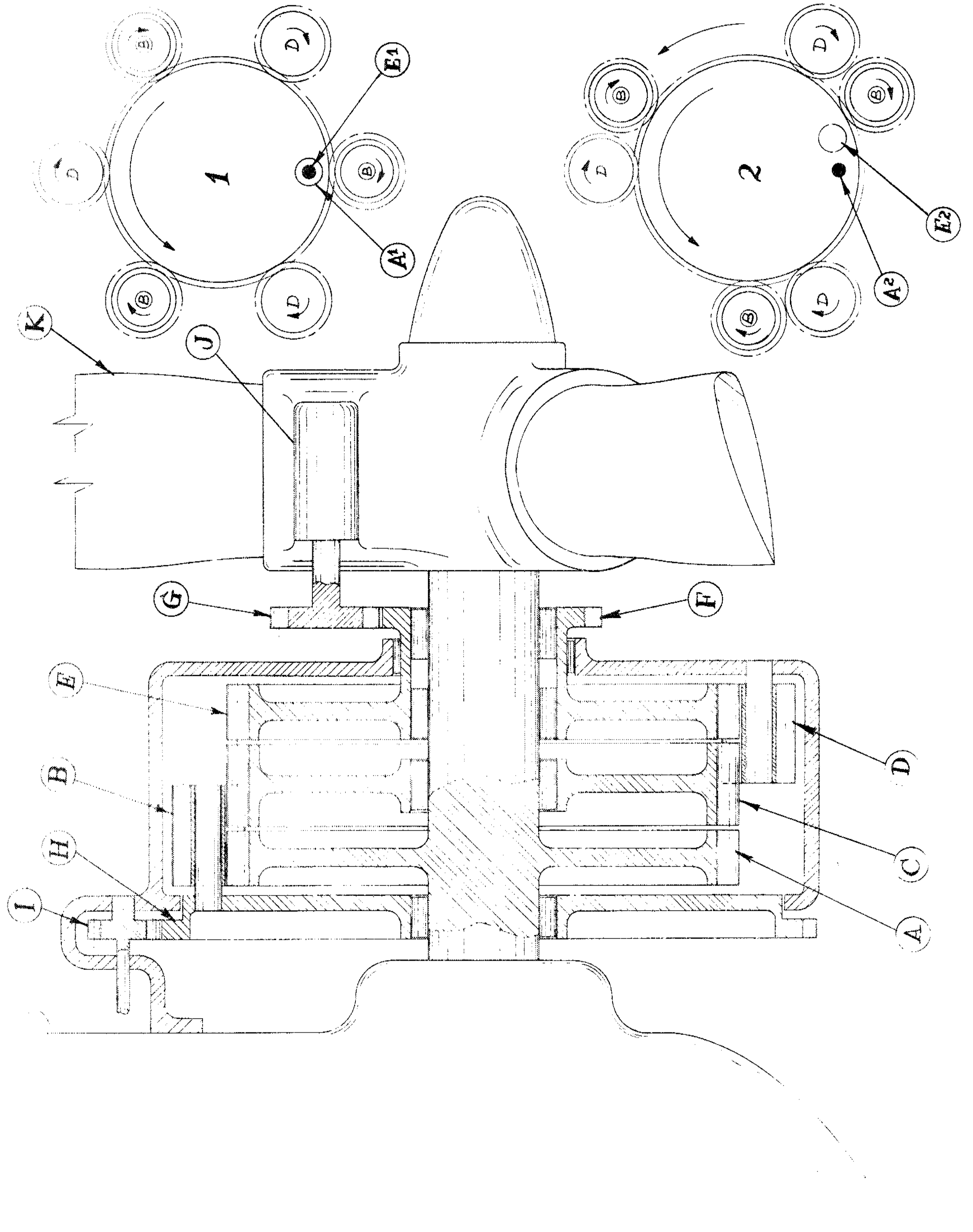

Fig. 2 PROPELLER PITCH MECHANISM DIAGRAM Fig. 2

Chapter 3

FUEL AND OIL SYSTEMS

Chapter 3

FUEL AND OIL SYSTEMS

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Chapter 3

FUEL AND OIL SYSTEMS

FUEL SYSTEM

General Description

The major features of the Me110's fuel system are the use of self-sealing fuel tanks and electric-driven, immersed fuel pumps. Four main fuel tanks are housed within the wing structure, two within the nose section and two more aft of the monospar, with all tanks inboard of the engine nacelles. Provision is also made under each wing panel and outboard of the nacelles, for an extra-range tank, which can be jettisoned when exhausted. The front main-tanks are 100 gal capacity, while the rear tanks hold 70 gals each. This gives the airplane a normal fuel capacity of 340 gals. For long range bomber escort, the extra-range tanks bring the total to approximately 400 gals.

One electric-driven immersed fuel pump is used in each main tank, although the pumps in the aft tanks deliver fuel only to their respective front tanks. Two wobble pumps, of a simple diaphragm type, are mounted in the wheel wells and operated by handles at the pilot's left. These units draw from the front-tanks and supply fuel to the opposite engine. This seems to be the only provision for cross feed, as the immersed pumps in the front tanks supply fuel only to the engine on their respective side of the airplane.

Two edge-type strainers are mounted in series in the fuel supply line to each engine. These units are located in the wheel wells, and are readily accessible for cleaning.

Editor's Note: The technical data for this portion of the Messerschmitt Analysis was contributed by R. Soucek, Experimental Engineer, and H. S. Fowler Jr. Power Plant Analysis Engineer and D. S. Hooker, Research Engineer for the Engineering and Development Dept. of Vultee Aircraft, Inc.

Standard filler units are used on all four main-tanks, with the unused outlets of each being plugged. The caps are easily accessible for filling from the top of the wing. Vent lines from the filler units of each tank tee together and slope gradually to a point within the wing trailing edge.

A fuel quantity gage unit is located in each main tank. This consists of a cylinder about two inches in diameter, extending to the bottom of the tank and containing a float sliding on a shaft connected to a rheostat in the top of the gage unit. The rheostat arm is rotated as the fuel level changes by lugs on each side of the float being guided by spiraling channels. A fuel level indicator and tank selector switch are provided on the pilot's instrument panel.

A de-aerator is mounted beneath the engine, and functions to remove air and vapor from the incoming fuel. Its discharge is teed into the fuel by-pass line from the injector pump and carried to the rear main-tanks.

Operation of the Fuel System

Take-off is accomplished with the two front pumps, as operating the aft pumps would be useless for these feed only the front main-tanks. As the fuel-level in the front tanks begins to fall, the extra-range tanks under the wings automatically feed their fuel into the front main-t nks. A float valve is arranged to shut-off fuel delivery when the affected front tank is full, and thus prevent overfilling and loss of fuel. The float valve functions on delivery from both the extra-range and aft tank.

The automatic supply from the extra-range tanks is accomplished by the vacuum-pump discharge air-pressure being impressed directly on the surface of the fuel. A relief valve prevents excessive pressure.

The pilot has no way of gauging the fuel in the extra-range tanks, but so long as the front main-tanks show full it is obvious that the extra-range tanks are feeding. When the front main-tank level begins to fall, the extra-range tanks can be jettisoned by the pilot.

The pilot then switches on the aft main-tank pumps, and these continue to keep the front tanks full by delivering through the float shutoff valves. During normal operation, the simplicity of the system is obvious. A new pilot remembers only to turn on the two front pumps before starting the engines, to jettison the extra-range tanks when these are exhausted, and simultaneously turn on the rear pumps.

OIL SYSTEM

General Description

Oil is circulated through the engine by a pressure pump fed by gravity from the oil reservoir, and supplies both the lubricating system and the supercharger hydraulic drive-coupling. After passing through the engine the oil drains to the camshaft covers, where scavenging pumps force the oil through the cooler and back to the reservoir. All oil pumps are positive, mechanically driven by the engine.

Oil Tank

The oil tank is located above and aft of the engine, so that the pressure pump is gravity-fed under all conditions, except possibly during steep climbs. The total volume of each oil tank is 11.5 gals., but since space for expansion and foaming must be provided, it can be assumed that the normal capacity is about 7.5 gals. This equals a fuel/oil ratio of 27 to 1.

Oil Cooler

The oil cooler is curved to permit a neat installation in the propeller blast underneath the engine. Controlled oil cooling is reportedly provided by a variable-position air exhaust shutter, but no evidence of such an arrangement was found.

Temperature is measured as oil enters the pressure pump, and it is believed the gauge was located on the inner side of the engine cowling in a position visible to the pilot during flight.

Oil Dilution System

Oil dilution, to aid cold weather starting, is similar to the U.S. Air Corps practice. Fuel under supply-pressure is sprayed into the oil entering the oil tank, through a collar containing six 0.078 in. dia. holes, drilled radially around the return line.

SELF-SEALING FUEL AND OIL TANKS

General

The Messerschmitt Me110 self-sealing fuel and oil tanks are not as effective against 30 and 50 cal. gunfire as current American made self-sealing tanks, but are as effective as American self-sealing tanks built in 1939 and the early part of 1940. The installation of the Messerschmitt fuel tanks is superior to most current American installation both in regard to bullet-proofing and simplicity. Other facts and conclusions obtained by examination and test are:

(I) The Me110 had four self-sealing fuel tanks and two self-sealing oil tanks.

(II) Each tank is an independent semi-rigid unit.

(III) All tanks are easily installed, inspected and removed.

(IV) A minimum amount of metal is used on the tanks, and between tank and structure.

(V) The fuel tanks are comparatively bulky, thick, and heavy.

(VI) From the fuel side outward, both fuel and oil tanks are compsed of a layer of fibre, a layer of leather, and 3 layers of rubber.

(VII) Two fuel tanks showed 55% effective sealing against 20 shots of 30 and 50 caliber gunfire.

(VIII) One oil tank showed 67% effective sealing against three 30's and was blown open by one 50 caliber bullet.

(IX) The deterioration of the tanks due to aging and abuse may possibly have, but probably did not, appreciably influenced their performance.

(x) The workmanship on the tanks was excellent, and inspection stamps were plentiful.

Tank Installation

Each fuel tank is an independent, semi-rigid unit mounted in a rectangular frame encircling the tank in the chord plane. These frames are oval tubes, approximately 1 in. x 3 in. cross section, and made of a tough, rigid vulcanized fibre. Canvas and vulcanized fibre straps attached to the frame pass over, under and around the sides of the tank to form a cradle holding the tank firmly, yet not rigidly connected, within the frame. The frame, with cradled fuel tank, is attached to the wing structure with four large, hollow steel-bolts.

One oil tank is installed aft of each engine in a location near the top of the nacelle. The tank is firmly attached to, and suspended from, a rigid fibre structure by two canvas straps. The fibre structure is, in turn, bolted to the engine nacelle structure. No encircling plastic frame is used. While the oil tank cannot swing like a pendulum, a certain flexibility is allowed by the canvas straps.

Each fuel tank is a roughly trapazoidial shape, with generously rounded corners. Each tank has three openings in the top: one for the quantity gauge; one for the immersed fuel pump; and one serving as a combination filler opening, vent line connection, and overflow connection.

The tank wall is composed of five layers, which, from the fuel side outward, are:

(I) A 1/16 to 3/32 in. thick pressed or molded fibre shell.

(II) A 1/8 in. thick layer of tanned leather.

(III) A 3/16 in. layer of plasticized raw rubber.

(IV) A 1/64 in. layer of tightly-cured, nearly pure rubber sheet.

(V) A 1/8 to 3/16 in. cover of highly-loaded, black, vulcanized rubber.

The fuel tanks were evidently made by molding the fibre to form the two ends of desired shape and cementing them to I-section, riveted fibre ribs. The ribs serve both as structural members and as partial baffles. The center portion is made of a sheet of flat sheet fibre wrapped around and cemented to ribs and ends making a gasoline-tight container. The leather is wrapped tightly around the fibre shell and the joints scarfed and sewed. The raw rubber is wrapped around the leather and the seams overlapped. The thin rubber sheet is loosely wrapped around the raw rubber and its seams generously overlapped, so that most of the tank area is covered by two layers of this thin sheet. None of the layers are cemented to any other layer. The black-rubber covering is made in two pieces; one molded to form the bottom, sides and ends; and the other to form the top. The top overlaps the sides, and the two are held together by short canvas straps.

The openings for the gauge, fuel pump, and filler are molded fibre rings, cemented to the fibre shell and extending through the other layers. The outer black rubber cover is attached to each fibre ring by binding with wire. Steel studs are pressed into each ring; and the gauge, pump, and magnesium filler neck casting are attached to these studs.

Description of Oil Tanks

The oil tanks are constructed in the same manner and materials as the fuel tanks. Each oil tank holds 11.5 U.S. gals and has an opening at top and bottom.

Firing Tests

Firing tests on two fuel tanks and one oil tank were conducted by Vultee. 30 and 50 caliber machine gun bullets were shot into all tanks at a range of 75 ft. using both ball and armor-piercing ammunition.

The fuel tanks were installed and shot separately in a section of the original wing structure mounted in a jig which permitted firing from any angle or side. The fuel tanks were filled with 87 octane aviation gasoline 24 hours before firing, and this gasoline was used in the tanks during the firing tests. Micro-analysis of a small sample of gasoline found in the fuel strainer revealed that the German gasoline was very similar to our 87 or 90 octane aviation gasoline.

Single shots only were fired through the right-hand forward tank, entering through both the leading and trailing edges of the wing. Two single 50's and a burst of five 30's were fired into the right-hand rear tank, with the wing in a [illegible]° dive position and the shots entering through top and exiting through bottom of tank and wing. Shots were counted as leaks if liquid flowed through the wound more than two minutes after the shot was fired. Two 30 caliber shots on the rear tank were disallowed because they were above the liquid level. The results of the firing tests are summarized by the following table:

	R.H. Fwd. Tank		R.H. Rear Tank		Both Tanks		
	30's	50's	30's	50's	30's	50's	Total
Shots fired	5	7	5	5	10	12	22
Shots scored on	5	7	3	5	8	12	20
Leaks	1	4	2	2	3	6	9
% Sealing	80	43	33	60	63	50	55

The firing test on the oil tank was conducted by suspending the oil tank from a steel frame. A 60 deg. tumbling plate was placed in front of the tank in lieu of nacelle structure. The tank was filled three-quarters full of S.A.E. 60, Grade 120, Aeroshell oil heated to 185 deg. F. Three 30 caliber rifle bullets and one 50 caliber machine gun bullet were shot through the tank from front to rear. The results are summarized below:

	Oil Tank		
	30 Cal.	50 Cal.	Total
Shots fired	3	1	4
Shots Scored on	3	1	4
Leaks over 2 min.	1	1	2
% Sealing	67	0	50

The results of the firing tests on the fuel and oil tanks show that their overall effectiveness is quite low compared to current American fuel and oil tank installations. However, it is quite possible that current German tanks are substantially more effective than the ones tested by Vultee.

The leaks in the fuel tanks caused by 30 caliber bullets were not severe. One on the entrance side of the forward tank was caused by the bullet pushing a piece of the fabric support through the tank wall to hold open the wound. The other two, on the exit side of the rear tank, were only film leaks. However, all these shots were near the top of the liquid, and an increased head of gasoline would undoubtedly have caused greater leakage.

The performance of the fuel tanks against 50 caliber gunfire was even poorer than indicated by the score. Of the seven 50 caliber shots fired into the forward tank, only one came out below the liquid level and it did not tumble. There was, therefore, practically no possibility of exit leaks on this tank. Three of the entrance holes were steady stream leaks and one, only 2 inches below liquid level, was a film leak. Once started, none of the leaks sealed or diminished in intensity with time; the raw rubber, being largely soluble, was washed out of the wounds by gasoline.

The oil tank proved to be very poor. Two of the 30 caliber shots did not tumble and these did not leak. The other 30 caliber shot tumbled partially and caused a small stream leak at the exit, which did not close off. The 50 caliber bullet entered straight, tumbled inside the oil tank, and broke out a very large hole at the rear of the tank.

Examination of the fuel and oil tanks after the firing tests revealed that the fibre shells were badly split by both the 30 and 50 caliber gunfire.

Discussion of Tanks

Since the construction of the Messerschmitt fuel and oil tanks is identical, they will not be treated separately. The inner fibre shell has three functions:

it is a gasoline resistant container: provides semi-rigid support for the flexible leather and rubber layers and maintains the shape desired; and acts as a form over which the flexible materials can be assembled. The leather layer is probably to provide strength and enable the tank to resist bursting and tearing under the hydraulic ram generated by a high-speed projectile entering a liquid such as gasoline or oil. The plasticized raw rubber is to seal the holes caused by the bullets, probably by cold flow and swelling actions. The thin cured sheet is probably to hold the plasticized raw rubber in place during assembly, to prevent its sticking to the outer cover, and to provide a slip-plane between the raw rubber and the outer cured-rubber cover. The outer rubber binds the other materials together, protects them from abrasion, crushing, or other damage during normal use, and serves to return the plasticized raw rubber to plane after being punctured, so that it may seal.

The fuel tanks bore inspection stamps of May, 1940, and the oil tanks were stamped October, 1940; so they were probably designed at least a year prior to that time. As far as is known, in 1939, there were no American fuel or oil tanks which would effectively seal 50 caliber bullet holes and very few which would seal 30's. The Germans were the first to extensively use self-sealing fuel and oil tanks; and undoubtedly have improved their tanks since 1939 and 1940.

The principal disadvantages of the Me110 tank construction are:

(I) It is heavy (3 lbs/sq.ft.). Most American made tanks weigh about 2 lbs/sq.ft.

(II) It is thick. The average wall thickness of 11/16 in. is greater than most American made materials, which are less than 7/16 in. thick.

(III) The fibre shell splits considerably under gunfire, allowing the liquid to act over a large area.

(IV) The raw rubber sealing layer is quite soluble in gasoline, readily contaminates the fuel, and is easily washed away.

(V) The outer layer is weak, and splits or tears easily.

(VI) The tank cannot be readily repaired, but must be replaced after being subjected to gunfire.

(VII) The construction is complicated, necessitating a large proportion of hand labor, with resultant high cost.

On the other hand these tanks posess the following advantages:

(I) The tank is a semi-rigid unit facilitating handling and installation.

(II) The number of outlets is reduced to a minimum.

(III) The amount of metal near the tanks is held to a minimum.

The tanks were out of service nearly a year before the firing tests were conducted. During this time, the tanks were subjected to rather severe weathering which, some observers felt, might have influenced the results. However, this is improbable. The fibre shell was found to be resistant to aviation gasoline similar to that found in the Me110 fuel strainer. The fibre was readily softened by water, and water softening could have been used in forming the fibre. Even if the fibre were less brittle and did not split so badly, it is doubtful if the performance would have been better; since the tears in the leather and rubber were considerably smaller than the splits in the fibre. The outer black rubber cover was undoubtedly deteriorated by sunlight, salt water, and aging. This would effect its snap or resiliency, but inspection showed that the outer rubber returned fairly well in plane around the punctures. It is doubtful if the leather or inner rubber-layers were deteriorated by aging, since they were well protected.

Discussion of Installation

In contrast to the poor performance of the tanks themselves, the installation is, in general, very good. It is evident that great pains were taken to design a structure particularly well suited to leak-proof tank installation. Both inside and outside surfaces of the skin are heavily coated with paint which probably reduces sparking. The hat-section stringers are formed instead of extruded to reduce the shrapnel effect which occurs when a bullet pierces an extrusion or casting. The wing ribs are far apart to make possible the use of large tanks, which are lighter per gallon than small tanks: dissipate the shock caused by a bullet into a larger volume of fuel; and greatly diminish the speed of the bullet by traveling a longer distance through fluid. Three out of five of the 30's and three out of seven of the 50's fired into the nose of the forward tank did not exit. The tank is spaced two or three inches away from surrounding structure, minimizing the cutting action of metal orange-peel. The strap attachment of tanks to frames provides flexible shock-absorbing suspension without concentrated support loads. The frames are attached to the wing structure with only four bolts, and a large removable skin panel is directly below each tank; so tank installation, inspection, and maintenance are relatively simple.

TABLE I

WEIGHT AND MEASURES OF THE Me110 TANKS

	Thickness inches	Weight lbs.	Capacity U. S. Gal	Specific Weight lbs/gal	Specific Weight lbs/sq.ft
Forward Fuel Tank	5/8 to 3/4	118.0	100.0	1.18	3.0
Aft Fuel Tank	5/8 to 3/4	123.0	70.0	1.76	3.0
Oil Tank	5/8 to 3/4	38.4	11.5	3.34	-

Weight of tanks includes fibre and magnesium fittings, ribs, etc.

Weight of oil tank is wet.

TABLE II

PROPERTIES OF RUBBER LAYERS

	Plasticized Raw Rubber	Cured Outer Rubber
Physical Properties		
Specific gravity	0.95	1.25

(Table II cont'd.)	Plasticized Raw Rubber	Cured Outer Rubber
Hardness (Shore A)	-	.69
Tensile strength @ break, lbs/ sq. in	-	11.29
Stress @ 300% elong. lbs/sq. in	-	21.21
Elongation @ break %	-	4.66
Plasticity @ 212°F.	150	-
Plasticity @ 78°F.	320	-

TABLE III

DESCRIPTION OF SUPPORT CRADLE

(i) The base material is a vulcanized fibre.

(ii) The fibre was made from paper-to-paper board layers.

(iii) The cementing material was urea-formaldehyde-resin.

(iv) The lacquer coating was urea-formaldehyde-alkyd resin, probably oil modified.

FUEL SYSTEM

SECTION II CHAPTER 3

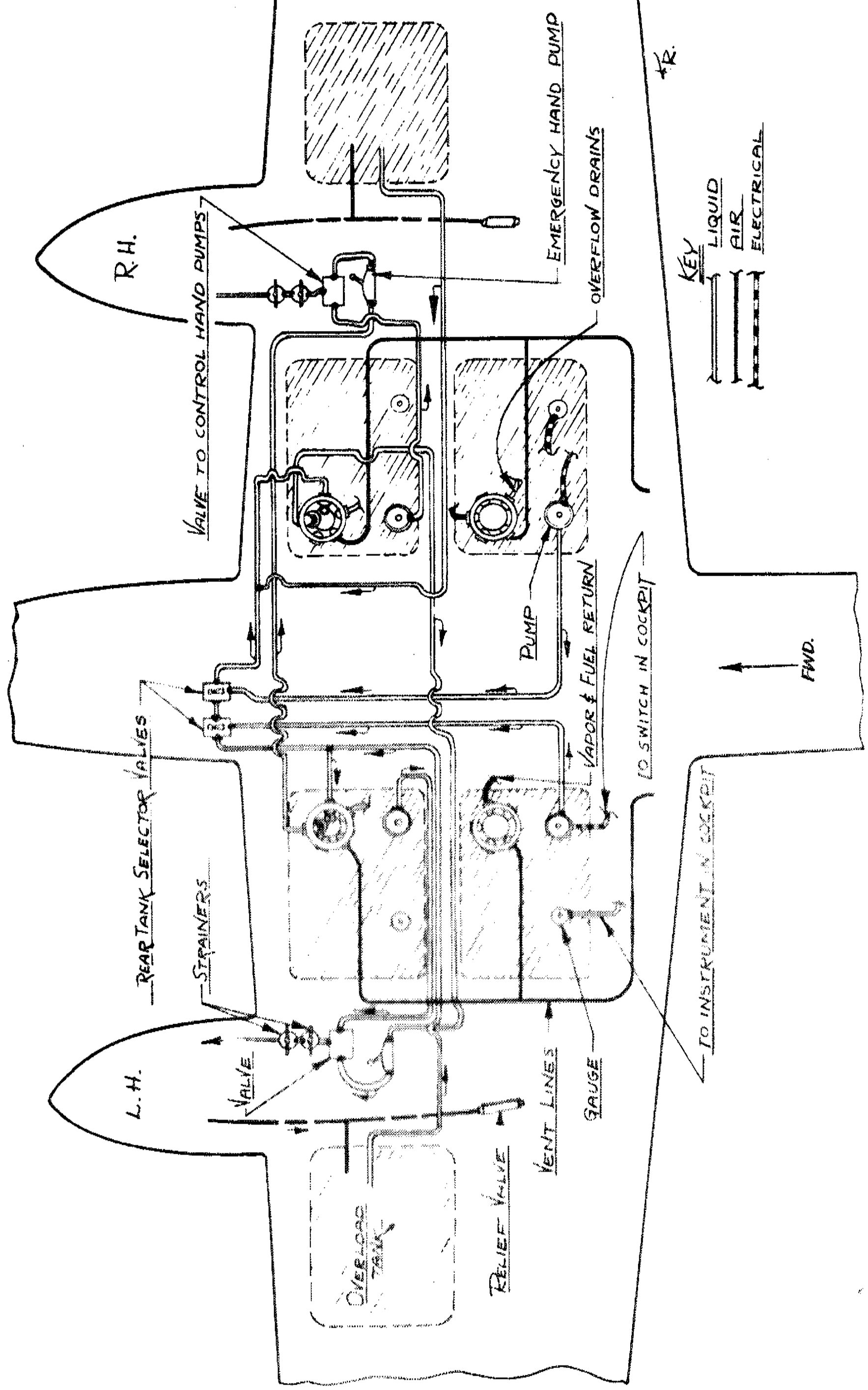
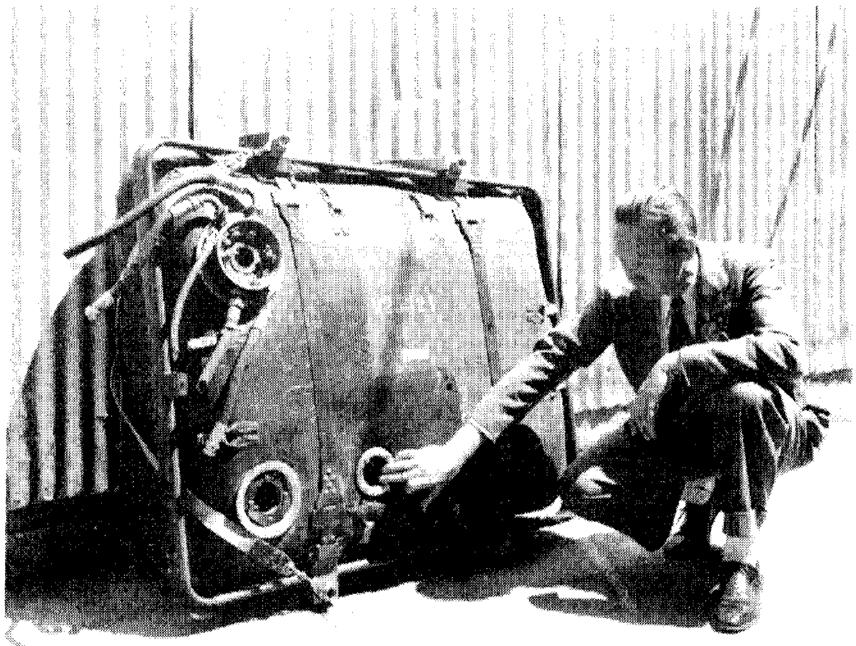


FIG. 1 **FUEL SYSTEM DIAGRAM** FIG. 1

FUEL SYSTEM



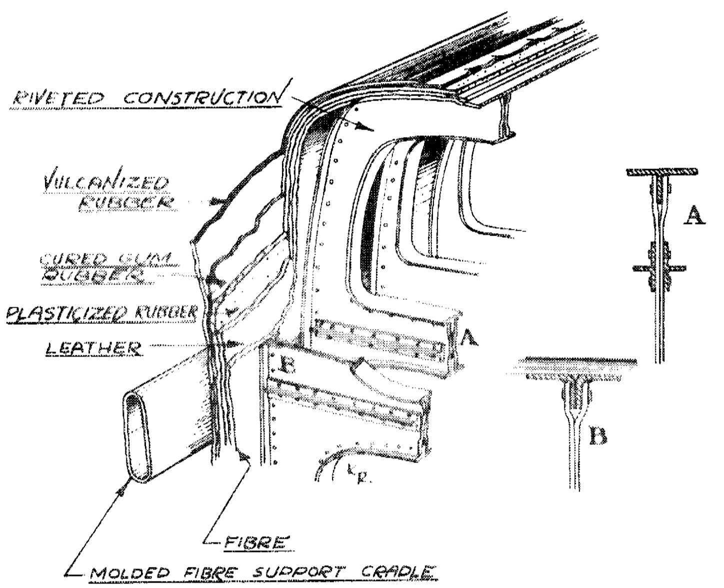


FIG. 2 FUEL TANK & CROSS SECTION FIG. 2

FUEL SYSTEM

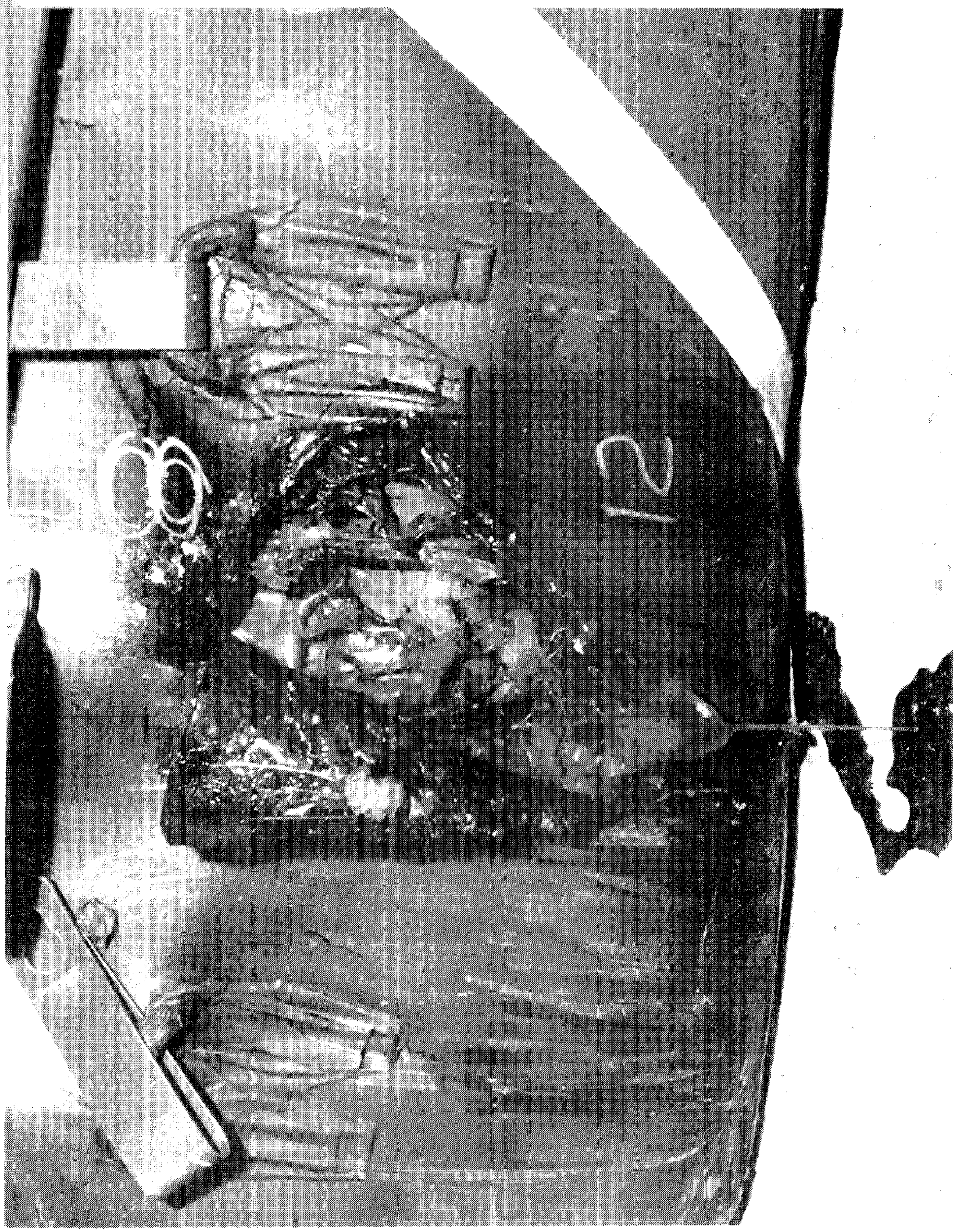
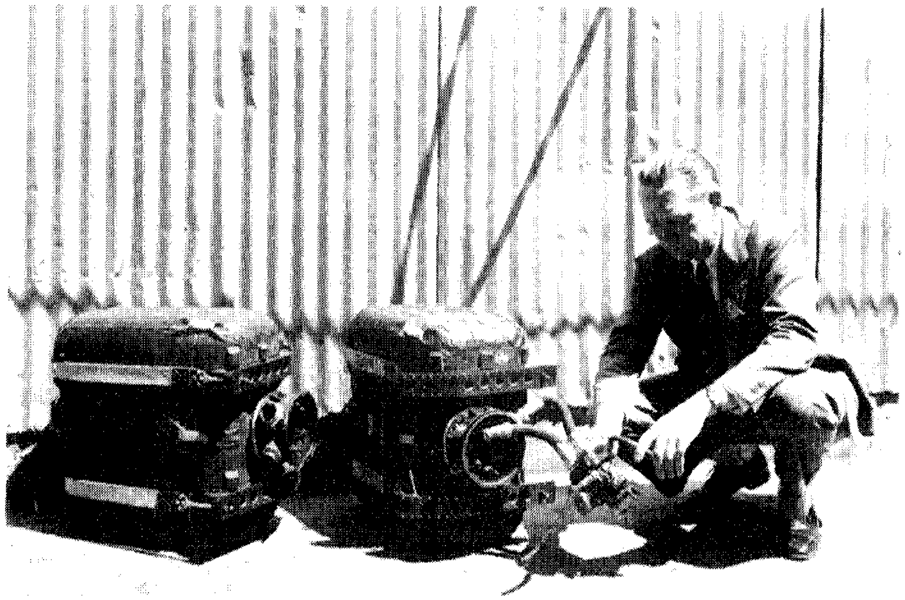


FIG.3 FUEL TANK FIRING TESTS FIG.3

OIL SYSTEM

SECTION 11 CHAPTER 3



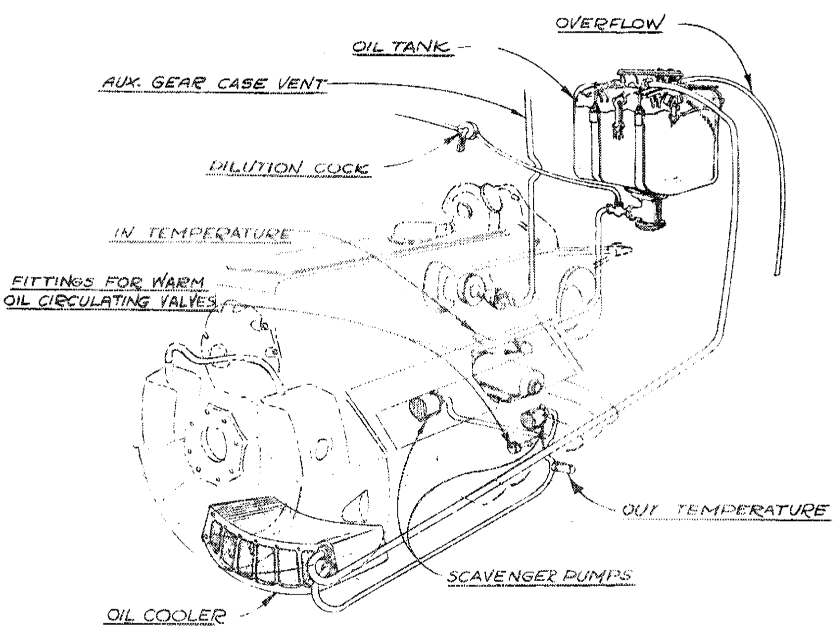
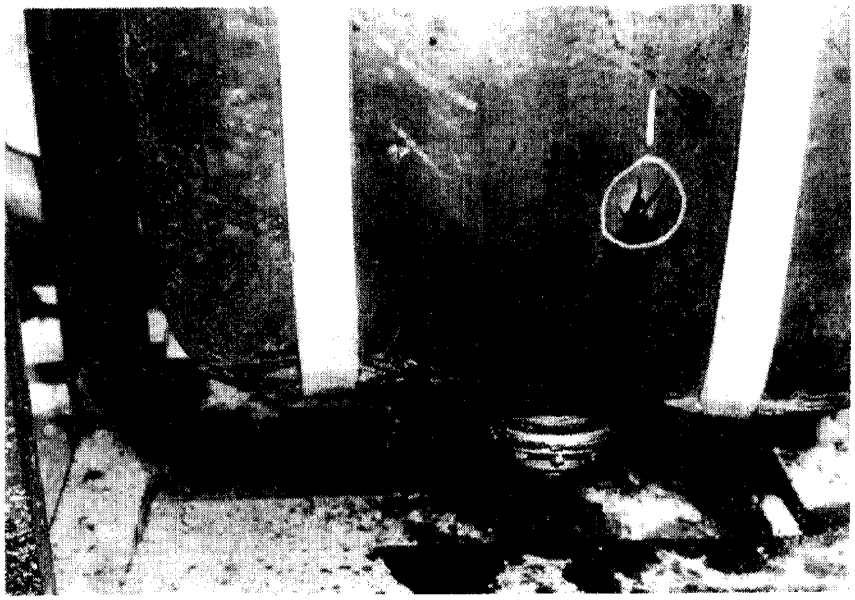
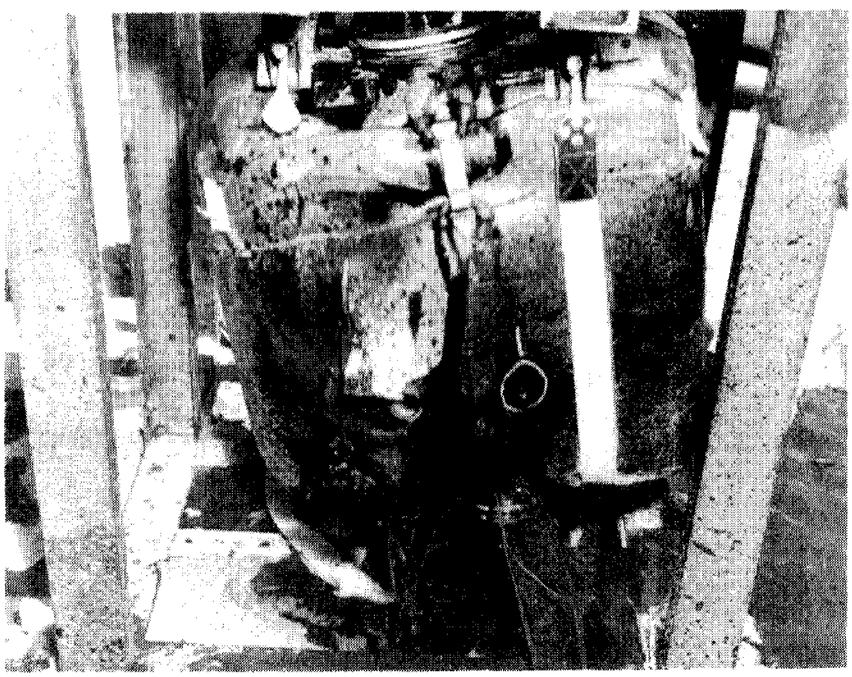


FIG. 4 OIL TANKS & SYSTEM DIAGRAM FIG. 4



EFFECT OF THREE 30 CALIBER SHELLS



EFFECT OF ONE 50 CALIBER SHELL

FIG. 5 OIL TANK FIRING TESTS FIG. 5

Chapter 4

COOLING SYSTEM

SECTION II

Chapter 4

COOLING SYSTEM

General Description

A coolant radiator for each engine is provided beneath the wing, in positions immediately outboard of the engine nacelles and just forward of the wing flaps. Each radiator has an electrically controlled air exit shutter. The absence of a rear spar at these locations permits the radiators to extend upwards for the depth of the wing, greatly minimizing the exposed, or frontal area presented to the air stream. This fact, in conjunction with placing the radiators in a location where a disturbance of air flow will have slight effect on the wing efficiency, gives the Me110 an extremely favorably coolant radiator installation. Coolant is a mixture of 50% ethylene glycol in water.

Operation of Cooling System

The coolant is circulated by a centrifugal pump located between the aft ends of the cylinder blocks. The coolant is conducted from this pump to the intake sides of the cylinder blocks, to enter the lower, aft end of the coolant jacket. After circulating through the jacket the coolant is discharged through a port at upper, front exhaust-side of the block, and conducted to the expansion tank. The coolant outlet temperature is measured by an immersed-bulb thermometer, indicating on the pilot's instrument panel. The coolant passes from the expansion tank to the wing radiator, through the radiator, and returns directly to the coolant pump.

The extreme upper, aft portion of each coolant jacket is vented to the

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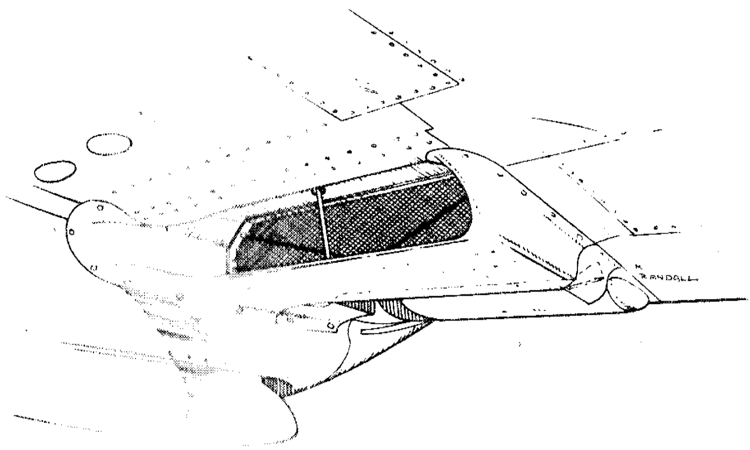
Editor's Note: The technical data for this portion of the Messerschmitt Analysis was contributed by R. Soucek, Experimental Engineer, and H. S. Fowler Jr. Power Plant Analysis Engineer for the Engineering and Development Dept. of Vultee Aircraft, Inc.

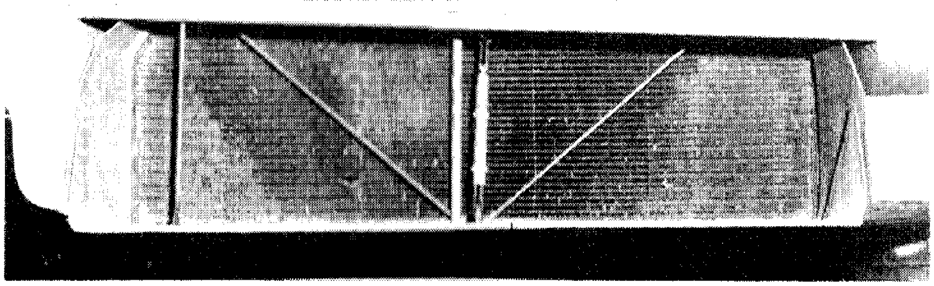
expansion tank to avoid steam pockets developing during dive conditions. The expansion tank is located at the front of the engine, around and below the propeller shaft. Double-acting relief valves at the upper ends of this semi-circular tank maintain pressure in the system between 14 and 19.7 lbs/sq. in. absolute, and are provided with drains to discharge surplus coolant overboard. A balance tube connects the upper ends of the expansion tank.

COOLING SYSTEM

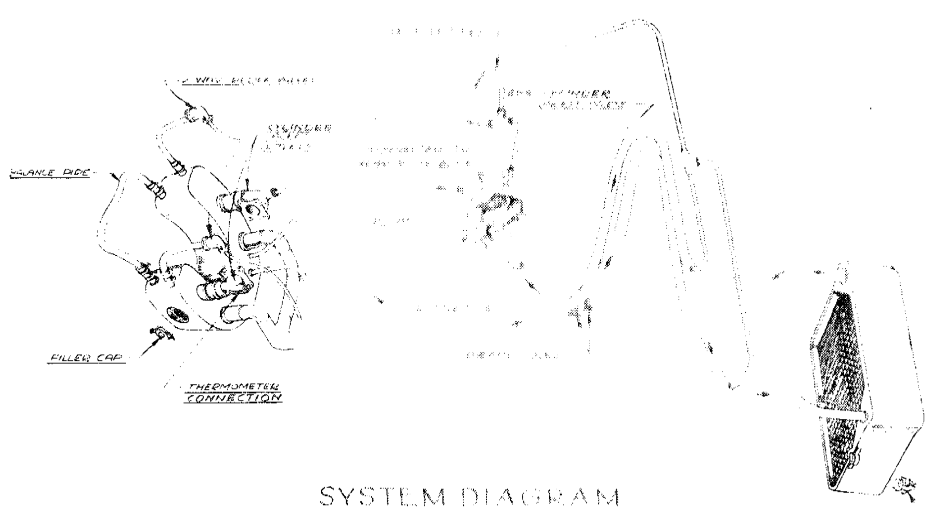
SECTION 11 CHAPTER 4



RADIATOR INSTALLATION



AFT SIDE OF RADIATOR



SYSTEM DIAGRAM

FIG. 1 ENGINE COOLANT SYSTEM FIG. 1

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EQUIPMENT

SECTION III

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SECTION III

Chapter 1

FLIGHT CONTOLS

General

Among the interesting features of the Messerschmitt Me110 flight controls system are: -- (1) Interconnection of flap operating mechanism with the ailerons and horizontal stabilizer; -- (2) Absence of a surface control lock;-- (3) Pilot's controls designed as a bench assembly with the pilot's seat: -- (4) Use of self-aligning ball-bearings at practically all wearing surfaces; -- (5) Use of push-pull rods, steel wires, and torque tubes for control linkage; and --- (6) One-man flight controls provided throughout, without duplication of controls in the aft cockpits.

Pilot's Control Stick and Mechanism

The pilot's control stick and mechanism is designed for installation as a unit assembly. This comprises two longitudinal channels attached at each end to the airplane structure to support rudder pedals, pilot's seat, and control stick as a complete bench assembly.

Elevator and aileron torque tubes are of steel members welded to forged and sheet-steel levers. These welds, in common with other welded joints in the airplane, are simple butt-joints, rather than the fish-mouth or diagonal joints used by American designs.

The control stick is a steel tube bent aftward directly above the

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. W. Withee, Group Leader in Charge of Flight Controls Design for the Engineering and Development Department of Vultee Aircraft, Inc.

stick socket fitting, and then forward to a vertical position at the handgrip to give an overall length of 27-1/2 inches. Shielded electrical wiring for the machine gun, cannon and bomb-release control switches in the stick hand-grip is clipped to the stick's forward side.

The control stick hand-grip is molded hard-rubber, shaped with finger indentations on the forward side and a slight forward and leftward tilt. The stick movement measured at the top of the hand-grip is 18 in. from neutral in all directions.

All stick mechanism bearings are unshielded ball-bearings, with a leather grease-retainer washer held against each side by a very thin metal strip bent into "U" shape around the bearing. Bearing retainer nuts are not required on torque tube axle bearings, as the tube ends are turned down to form stubs extending through each bearing. Bolts and tubular-rivets are used to attach torque tube fittings, and taper pins are conspicuous by their absence. Push-pull rods are used for elevator and aileron control linkage in the cockpit, with self-aligning bearings used for connection to the related bellcranks.

An interesting connection is used between control stick and elevator torque-shaft. This consists of link 4-1/4 in. long, connecting between the stick socket at a point 5-1/4 in. above the pivot-point and an arm welded to the elevator torque shaft. Aileron movement does not affect elevator movement when the stick is in neutral position, but when the stick is either forward or aft of neutral a slight elevator movement is obtained when the ailerons are moved.

Pilot's Rudder Pedals

The rudder pedals pivot from the bottom to operate push-pull rods interconnected by a torque tube beneath the pilot's seat. The arrangement is quite conventional, and is similar to the rudder pedal mechanism used by many American airplanes. The pedal and brake-linkage movement is approximately a parallelogram motion.

Each pedal is a cast magnesium-alloy grill provided with an integral heel plate, and a tube bent over the top to form a stirrup. The pedal is connected to the pedal arm by a small pressed-in axle tube pinned to a clevis formed on the pedal base. The pedal clevis straddles another clevis in the end of the pedal arm, and within the pedal arm clevis there is a short arm extending forward to connect with the master brake cylinder piston rod, and pinned to pedal axle-tube. A short vertical link rod connects between the tip of pedal and the piston rod. The lower end of the brake master cylinder is hinged to a point slightly forward of the pedal arm pivot point. Thus, fore-and-aft movement of the brake pedal operates the rudder without appreciable movement of the brake cylinder, and tilting of the pedal operates the brakes without moving the rudder.

At a point midway between pedal pivot and pedal arm pivot is the connection for the operating push-pull rod leading to the rudder pedal interconnecting system beneath the pilot's seat. The rudder pedal inter-connecting system is a simple linkage system of steel tubes. A bellcrank on the rudder pedal inter-connecting system is linked to a push-pull tube extending aft to connect with a walking-beam. Steel wires extend aft from this walking beam to connect with the rudder mechanism in the tail cone.

Rudder pedal position-adjustment is obtained by small star-wheels which operate jack-screws connected between the forward end of the rudder pedal push-pull tubes and the pedals proper. This arrangement allows for varying the push-pull tube length 1-1/2 in., with a proportionate change of pedal position.

The 1/8 in. dia. steel wires connecting between rudder and elevator walking-beams in the aft portion of the gunner's cockpit, and the control mechanism in the tail cone are used in pairs; being held about 11/16 in. apart by clips spaced from 12 in. to 30 in.. Some of these clips are of micarta and others are steel, and all are two halves clamped together by a single screw. The wires are threaded at ends and screwed into small clevis-end fittings, which are pinned to a large clevis fitting. This large clevis fitting attaches to the operating mechanism by a 1/4 in. dia. bolt passing through a ball-bearing.

The rudder control wires are in pairs along the right side of the airplane, beginning at a vertical walking-beam, and follow a spiral course down the length of the fuselage to connect with a horizontal rocker-arm on the forward, lower part of the horizontal stabilizer. A torque tube extends through the stabilizer at this point to a rocker-arm on the upper surface. From this rocker-arm push-pull tubes extend outboard to bellcranks attached directly to the left and right-side rudders. Stops at the lower rocker-arm on the stabilizer limit rudder travel to 35 deg. left and right.

The control wires are fairleaded at three or four points throughout their length, by phenolic strips slotted for shifting of wires due to bellcrank movement. The control system operates very freely, as the complete absence of pulleys reduces operating friction to a minimum. Practically all bearings are double row self-aligning unshielded ball-bearing type.

The brake master cylinders are the compression type, with external reservoir, and are about half the size and weight of those in general use in this country for an airplane of comparable weight.

Aileron Controls in Wing

The aileron control within the wing comprises a group of push-pull rods and levers connecting between the aileron-drooping units at the fuselage, and the operating bellcranks at the ailerons. A push-pull tube connects between each operating bellcrank and its respective aileron. All of the mechanism within the wing can be inspected by removal of stressed-panels attached by machine screws in the wing lower surface.

Aileron tabs are adjustable on the ground only, by means of a turnbuckle connecting between each tab and aileron. These tabs are for trim only; as no servo action is provided.

From an assumed spanwise loading distribution on the wing the applied loading in the low angle of attack condition is 116 lbs/sq.ft. The design loading would then be 174 lbs/sq.ft. The design aileron hinge moment using a 4/3 - 2/3 loading of 174 lbs/sq.ft. would be 11,300 in-lbs. Since it would take a design load of 945 lbs. on the stick in the cockpit to produce an 11,300 in-lbs. moment on the aileron, we can assume that this aileron have very effective leading-edge aerodynamic balance.

Wing Flaps and Slats

The wing flaps are conventional aileron-type, with the hinge below the lower surface. Operation is provided by a torque shaft extending across the fuselage, and carrying a bellcrank at each end; from which a push-pull rod extends aft to connect with the inboard end of the respective flap. Power for flap operation is provided by a hydraulic actuating cylinder connected to the left-side bellcrank. Emergency operation is provided by a compressed air system.

The left-side bellcrank also connects to a toothed rack extending aftward to operate a cable drum by means of a spur gear. A cable extends aftward from this drum to a length of roller chain passing around a sprocket driving a screw-jack connected to the horizontal stabilizer leading edge. The arrangement is such that the leading edge of the stabilizer is lowered about two inches when the flaps are lowered.

There is a small Bowdenite cable extending forward from the torque-tube arm to a flap position indicator in the cockpit.

The wing flap torque-tube is connected to the aileron system to droop the ailerons when the flaps are lowered. This is accomplished by ingenious toggle mechanisms connected to the aileron push-pull tubes to give the effect of varying the length of these tubes when operated by movement of the wing-flap torque-tube.

Each wing slat is fastened rigidly to a large channel-section, which in turn is attached to the wing structure by a heavy chordwise link pinned to two levers to form a parallelogram linkage. A push rod extends aft from each link to connect with a bellcrank located aft of spar. A spanwise push-pull tube connects between the two bellcranks to balance the fore and aft movement of the slat.

The inboard bellcrank is equipped with an unused bearing, apparently for interconnection with the wing flaps to insure complete opening of the slots whenever the flaps were opened. In fact, a description of an early-model Messerschmitt appearing in an English aeronautical magazine states that slats and flaps are interconnected. However, it would appear that this was found undesirable, and eliminated on later models.

Elevator Tab Control

The elevator tabs are operated by a hand wheel located at the left-side of the pilot's cockpit. The controls in the cockpit are conventional, but the method of actuating the tabs is quite unique, as torque tubes rather than cables are used.

Movement of the hand wheel in the cockpit rotates a 3/8 in. dia. rod by means of bevel gears. This rod extends the length of the fuselage to an irreversible nut and worm located near the horizontal stabilizer rear spar. The nut is carried by a short clevis arm connected to a spanwise torque tube extending along the stabilizer rear spar. This torque tube terminates at the left and right-side tabs, and is fitted with levers connecting to push-pull rods linked to the tabs. Due to the forward lever being off-center from the elevator hinge line, the tabs have servo-action as well as trim. Approximate tab movements are: 25 deg. up and 30 deg. down for both trim and servo.

A very simple position indicator is provided for the elevator tabs. An operating torque rod is threaded near the hand wheel, and a special nut with a pointer fits on the threaded portion to move fore-and-aft along a scale when the hand wheel is turned.

Rudder Tab Control

The rudder tab is operated from the pilot's cockpit by means of a control lever mounted horizontally at the right side of the cockpit. The arm has a pointer which is spring loaded against a notched quadrant graduated to indicate the tab positions. Spring and quadrant are depended upon to prevent shifting of the tab setting.

A vertical shaft from the control arm is fitted to a gear meshed with a rack to give fore-and-aft movement to a rod extending to the aft end of the fuselage.

A bellcrank at the centerline of the horizontal stabilizer changes the push-pull rods fore-and-aft movement to a spanwise motion, which is transmitted to the tabs by means of push-pull tubes, bellcranks, and linkage at the tabs.

FLIGHT CONTROLS

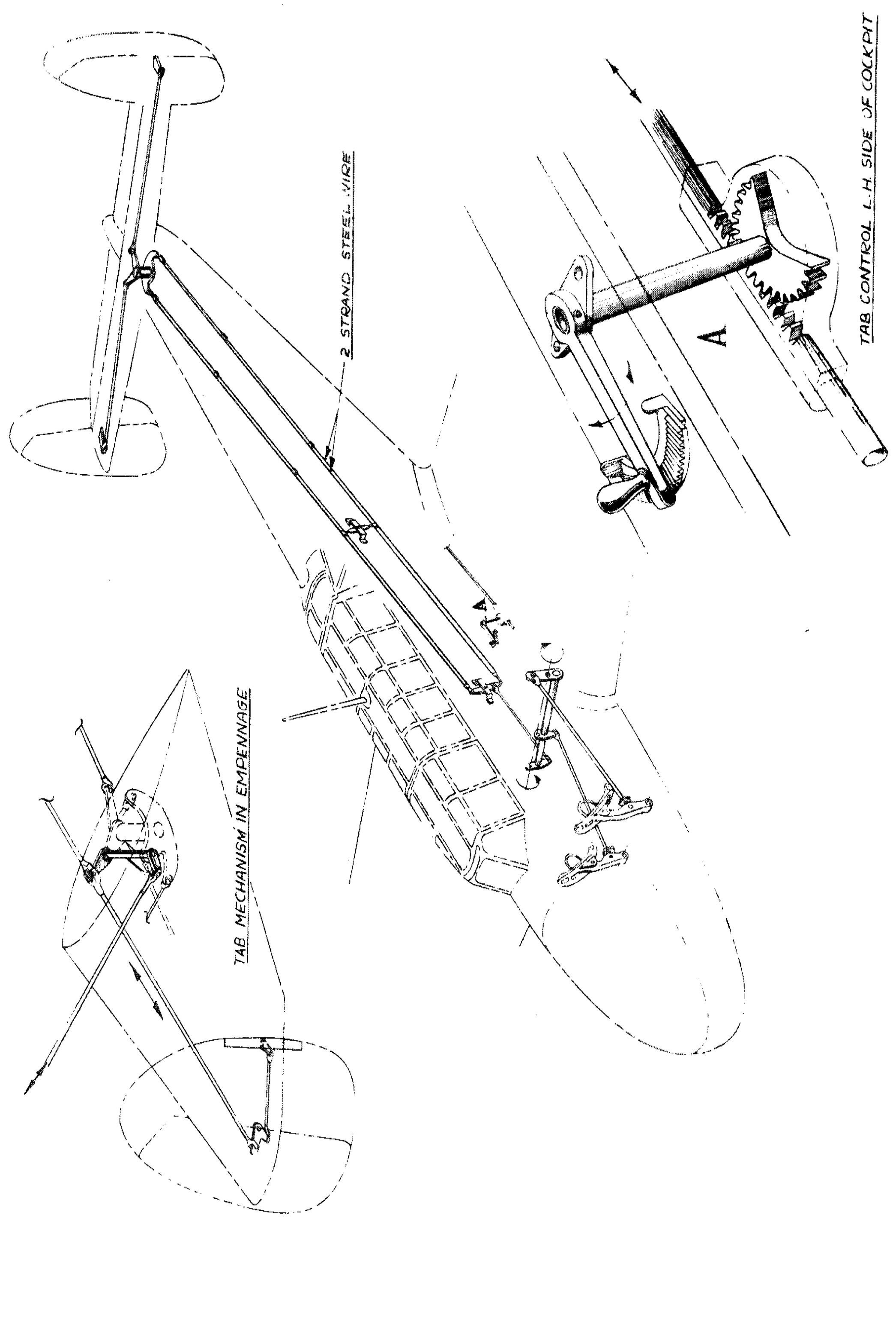


FIG. 1 RUDDER & TAB CONTROLS FIG. 1

FLIGHT CONTROLS

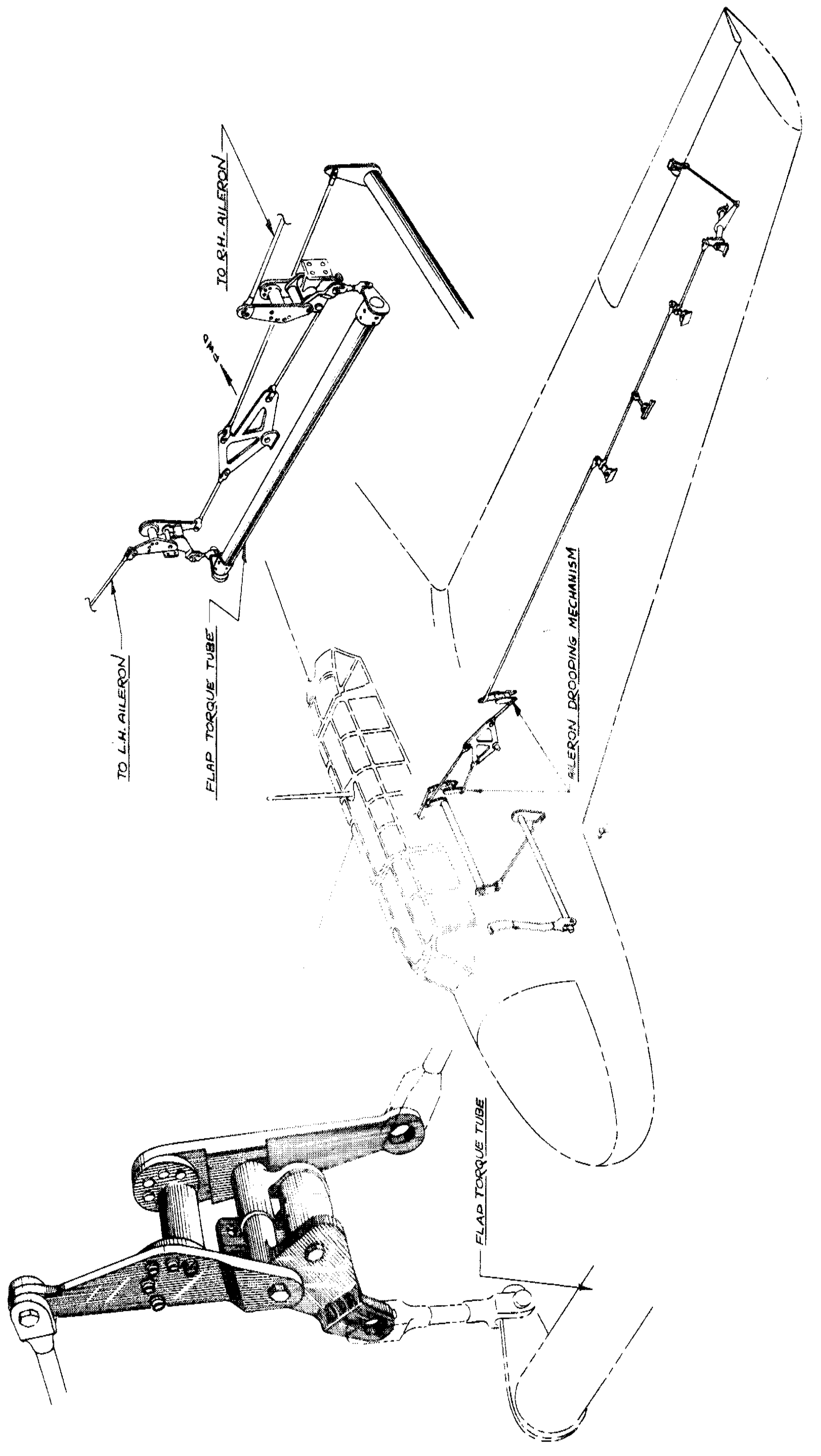


FIG. 2 **AILERON CONTROL MECHANISM** FIG. 2

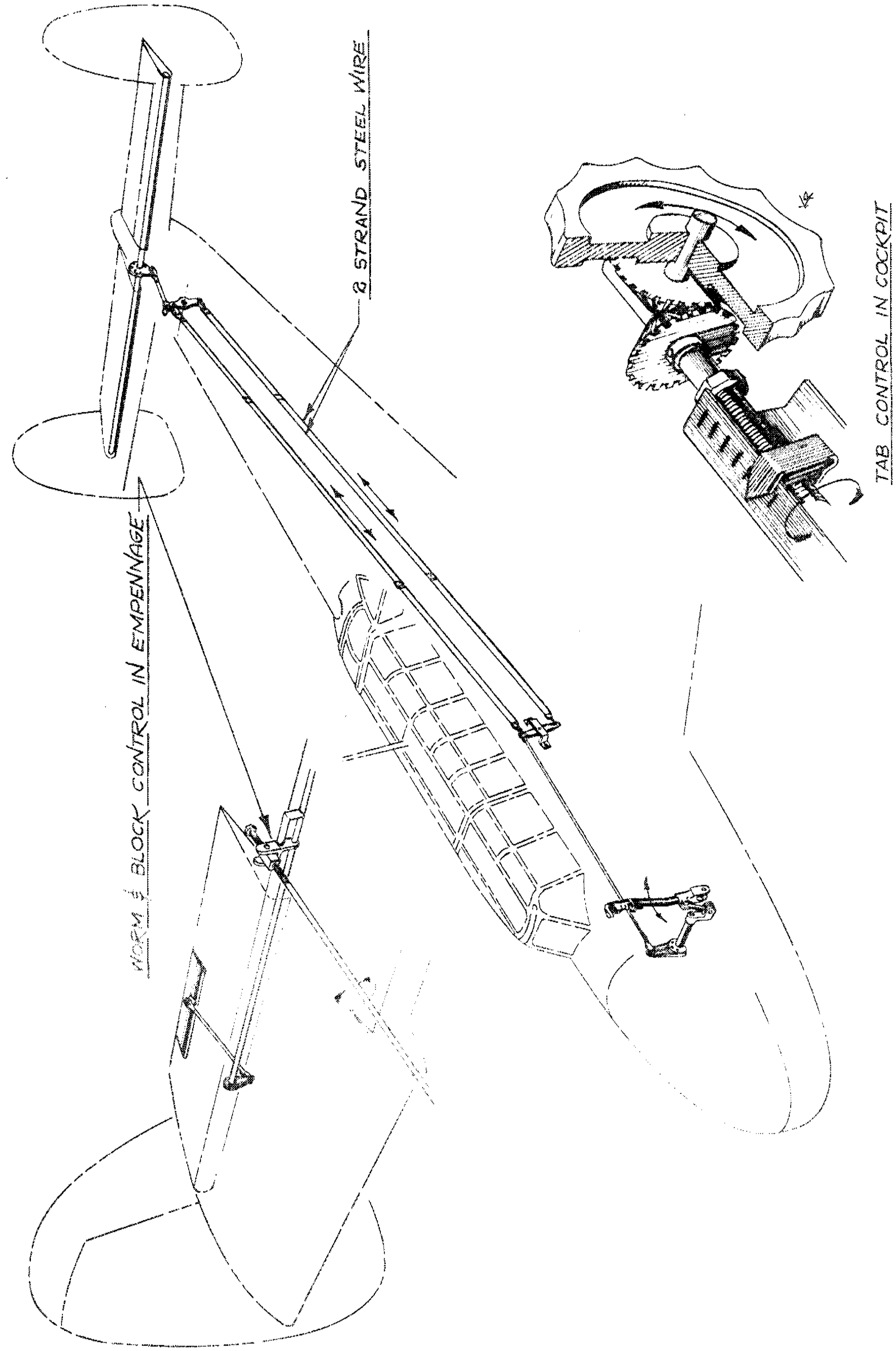


Fig. 3 ELEVATOR & TAB CONTROL Fig. 4

FLIGHT CONTROLS

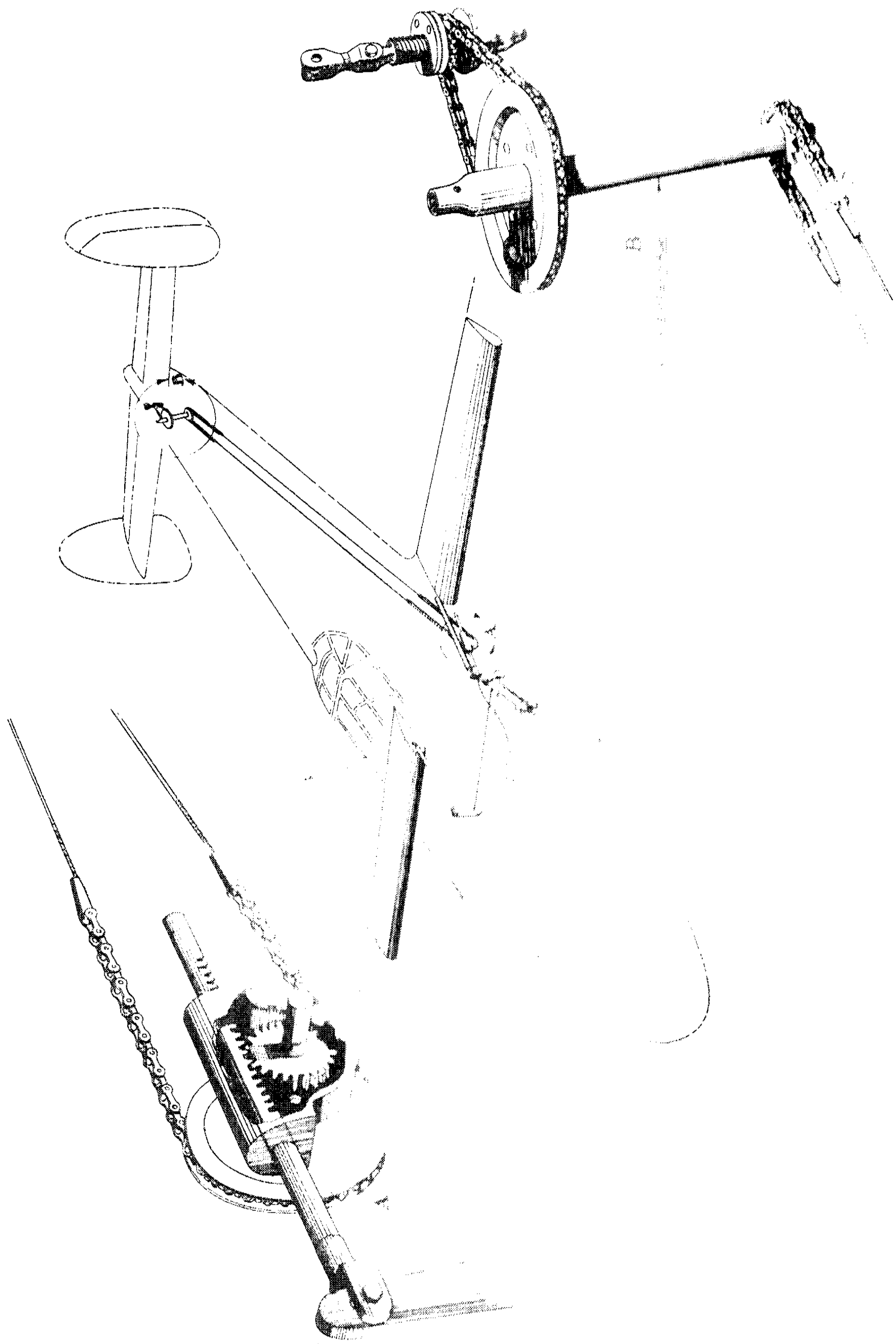
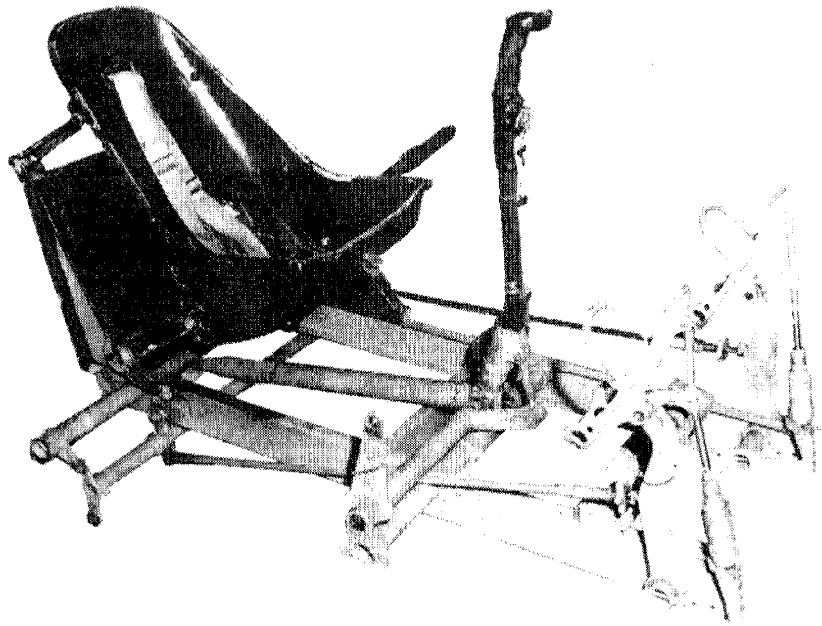


Fig 4 WING FLAP & ELEVATOR CONTROL MECHANISM Fig 4



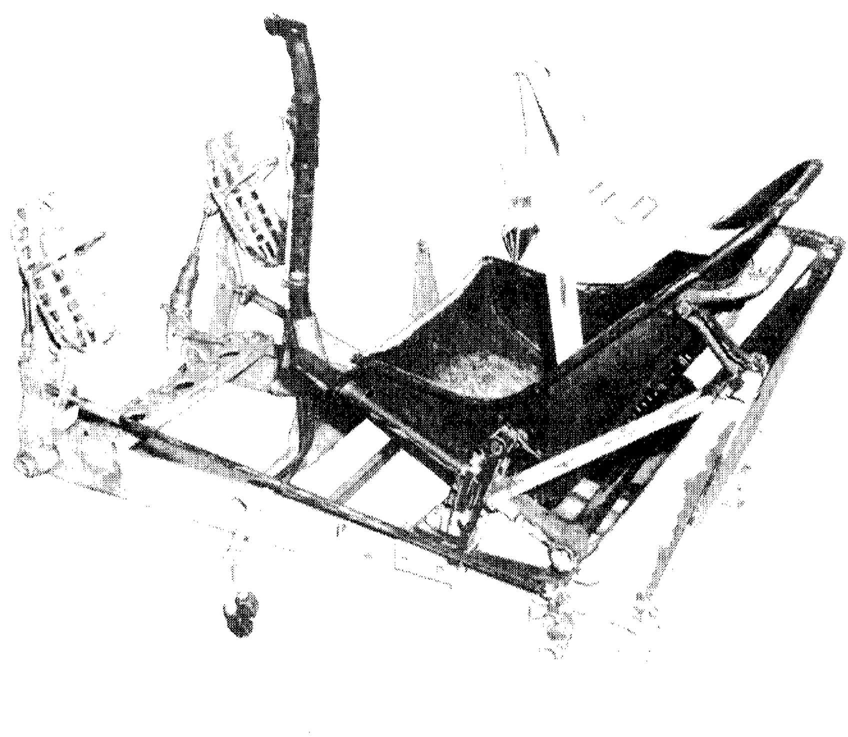


FIG. 5 PILOT'S CONTROLS ASSEMBLY FIG. 5

FLIGHT CONTROLS

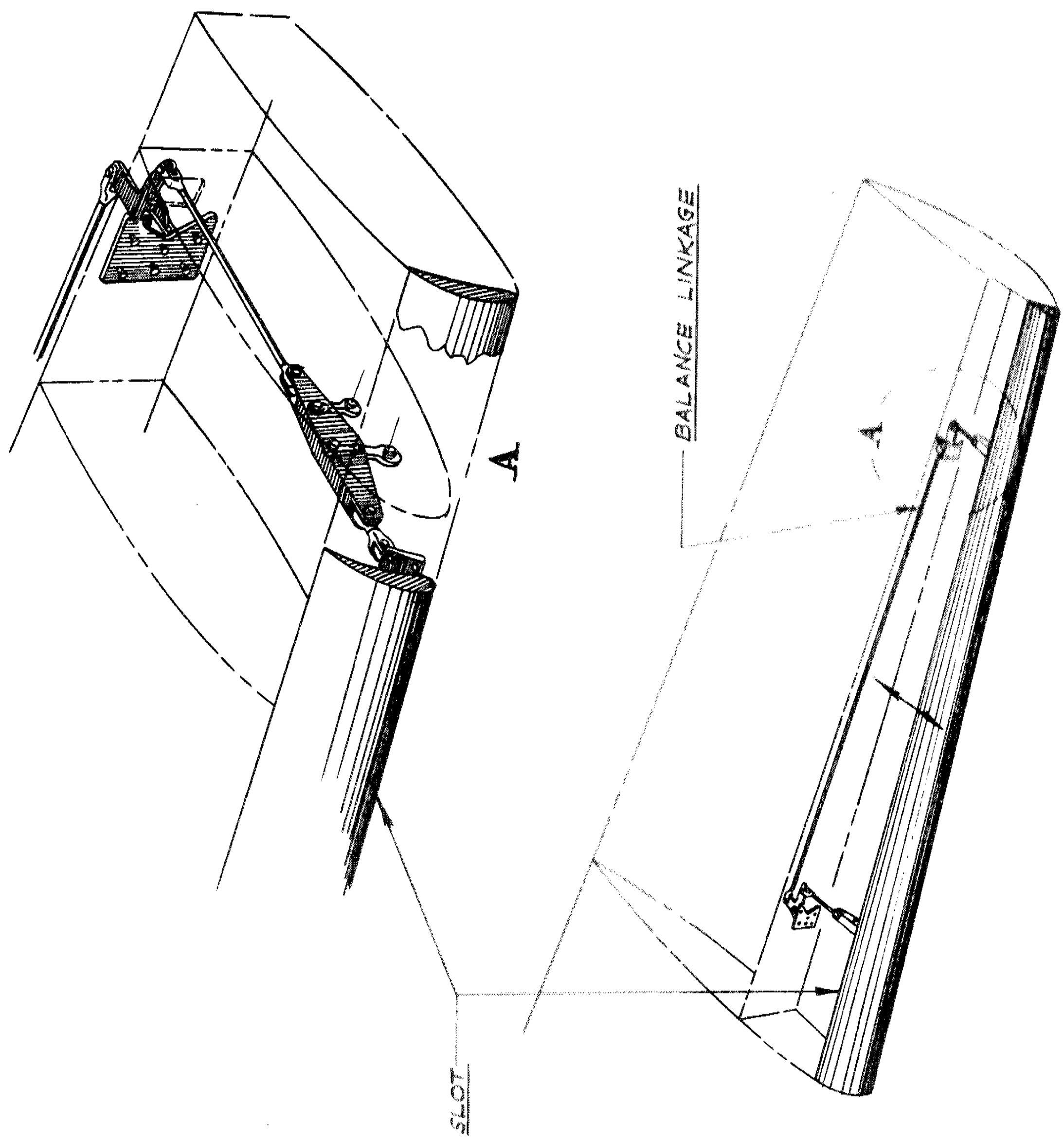


FIG. 6 WING SLOT MECHANISM FIG. 6

Chapter 2

HYDRAULIC EQUIPMENT

Chapter 2

HYDRAULIC EQUIPMENT

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Chapter 2

HYDRAULIC EQUIPMENT

General Description

The Messerschmitt's hydraulic system reveals several interesting innovations from American practice, the most outstanding being simplicity of the system itself; made possible by elimination of secondary units, such as pressure regulators and accumulators. The schematic system diagram shown at Fig. 1 is believed to be accurate, but as the hydraulic system was partially dismantled before the airplane reached Vultee, it was necessary to reconstruct the circuits by logical deduction. The working pressure of the system is estimated to be between 1500 and 2000 lbs/sq.in., as an emergency air actuating system charged to about 2300 lbs/sq.in. is provided.

The left side engine nacelle accommodates a landing gear actuating cylinder and two hydraulic lines which lead from the cylinder and join the right hand cylinder lines at the side of the fuselage. The right side engine nacelle accommodates a landing gear cylinder, engine driven hydraulic pump, system relief valve, and filter and reservoir tank, all interconnected by short lines.

Suction, pressure, return and the two landing gear cylinder lines lead from the right side engine nacelle. The suction line leads to the emergency hand pump; the pressure line from the hand pump leads to a "two-way" directional valve located directly above the hand pump; with both units being located at the left side of the gunner's cockpit.

Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. J. M. Hudson, Group Leader in Charge of Landing Gear and Hydraulic Design for the Engineering and Development Dept. of Vultee Aircraft, Inc.

There is no accumulator used in this system and no independent pressure regulator, as the pressure is governed by maximum pressure relief valve setting, and pump delivery being by-passed to the reservoir by automatic neutral, open-center type selector valves except during the period of system operation.

One filter and one pressure relief located in the right engine nacelle pass the fluid to the system, all units being operated at the same fluid pressure. The filter is quite small, and similar to the Cuno Auto-Kleen.

All lines in the fuselage are quite short, and nested to the fuselage to present a small target. The nesting or grouping of lines at the fuselage presents a very serious service handicap, as many lines are inaccessible at fuselage bulkheads.

An independent compressed air supply is provided for emergency operation, and a hand pump for manual operation of landing gear and wing flaps. The emergency air system consists of a pressure bottle, selector valves and automatic fluid by-pass valves.

The compressed air system is light, simple and easily serviced, connections being furnished for recharging the air bottle from an exterior source. Our only criticism of the installation is that the air lines to the actuating cylinders are nested with the hydraulic lines, making it possible for both hydraulic and air systems to be rendered inoperative by a single projectile.

Lines and Fittings

The tubing used for the hydraulic lines is soft aluminum-alloy similar to our 2S 1/2H. The ends of the tubes are secured by three piece couplings, comprising a nut, flared clamping ring, and liner to seal between the tube and fitting. All tube assemblies are painted brown their full length, and flow arrows are painted at intervals. Many fittings are eliminated by generous use of flexible hose; the manner in which the lines are routed; and by welding where it is necessary to join lines.

All end fittings are standardized, to eliminate adapters, reducers and unions in the lines. Bulkhead fittings are provided where the lines pass through the fuselage and wings. The connecting nuts on flexible lines are painted the code color after installation and adhesive bands with printed arrows are wrapped around the swaged part of the fitting to indicate direction of flow.

Flexible hose assemblies consist of an inner liner of synthetic rubber with a rubber impregnated woven cover surrounded by loosely wound wire. An additional woven cover over the wire wrapping is covered with an outer-layer of two thicknesses of impregnated fabric. Upon examination it was found that the outer cover, which is porous in nature, had deteriorated and become separated from the bonding material; permitting the wire wrapping to rust. The inner lining showed a tendency to crack in service. In general, these hose assemblies appear inferior to similar American components.

Compressed Air System for Emergency Actuation

The emergency air system for operating landing gear and wing flaps consists of an air bottle with built-in pressure regulator, two manually operated needle-type valves and an air-operated fluid by-pass valve connected to each actuating cylinder.

The air bottle is of conventional construction, with a diaphragm-type pressure regulator attached at the bottle. There are three outlets provided; to the outside of the fuselage for filling; to the pressure gage on the instrument panel; and to the selector valves situated just below the instrument panel. These valves are a simple needle-type, and are provided with a second needle for exhausting the system pressure to the outside air.

The automatic air valves, of which the flap cylinder valve shown at figs.

5 and 7 is typical, are basically a check valve, preventing hydraulic fluid entering the air system, and shutting off the fluid supply when the air pressure is used. Reference to figs. 5 and 7 will show that a spring loaded piston with a disc seal in each end normally rests against the air-port of the valve, allowing fluid to pass through the valve in either direction.

When sufficient air pressure is applied to the valve the piston moves away from the air inlet port and is forced against the fluid inlet port, thereby preventing the air from escaping into the fluid system or exhausting through a broken hydraulic line.

The air passage around the air-inlet end of the piston is sufficiently restricted to maintain a pressure on the piston great enough to overcome the load of the spring and force the fluid valve to seat. The air then passes through the valve into the actuating cylinder to extend the flaps or landing gear. As this is an emergency system no provision is made for retracting the landing gear or flaps.

No seals are used on the periphery of the piston, (but a close fit is used to prevent excess air or fluid loss during the movement of the piston).

Landing Gear Actuating Cylinder

The landing gear retracting cylinders, shown at figs. 3 and 4, while incorporating many unusual design features, appear unnecessarily complicated, expensive to manufacture and difficult to assemble and service. The mechanism employed to lock the piston at either end of the stroke offers the major cause for criticism. The lock is an integral part of the piston, engages by spring pressure and releases by hydraulic pressure. While automatic locks offer a great many advantages the locking mechanism of the Me110 has several unfavorable features.

A study of the cross section drawing at fig. 4, will show an excessive number of precision machined parts; a tendency for the locking elements to drag through the stroke of the piston; the difficulty of disengaging the locks for servicing; and the need of special tools to disassemble the cylinder for inspection and repair.

The locking action is obtained by the conical section of the spring loaded plungers forcing outward the balls radially disposed around the plungers. These balls cause the bronze segments of the locking ring to engage in the groove provided at the affected cylinder end.

Fluid entering the cylinder must displace the plunger allowing the balls and ring segments to be compressed inwardly by the angle of the locking ring groove in the barrel before the piston can move. As the pressure required to move the piston is not necessarily as great as that required to disengage the lock and start the piston moving, the plunger will attempt to return to the locked position, thereby creating a high friction drag between locking segments and cylinder wall.

Check valves are provided in each plunger to permit the displacement of the fluid between the plungers. These check valves permit the fluid to leave the cavity between the plungers but prevent its return, thereby eliminating to some extent the friction drag caused by the plunger springs. There is sufficient seepage from the outer case of the system to allow the plungers to assume their maximum stroke position.

The piston rod, the retracting portion of the piston seal and the cage for one element of the lock are integral, being machined from a steel forging. In the piston rod a means is provided to depress the extended-lock plunger, permitting disassembly of the cylinder.

The clamp ring for the retracting seal also acts as a bearing to locate the piston in the barrel. The seals are larger in cross section and of softer material than used in American practice, allowing positive sealing with [illegible] fluid pressures and slight misalignment.

The cylinder barrel is machined from cast steel. Each end is provided with an electrical lock-position switch operated from a plunger displaced by the locking ring segments. These switches are wired to indicator lamps on the pilot's instrument panel; arranged to glow until their respective locks are fully engaged. The cylinder ends screw into internal threads in the barrel and seat against flat packing rings. Snap rings are used to secure the elements of the lock and piston ends.

The landing gear actuating cylinders have a bore of 2-3/8 inches and a stroke of 14-1/2 inches. Although these cylinders are of steel, their weight, exclusive of the locking feature, compares favorably with American cylinders.

An automatic hydraulic lock is provided in addition to the integral cylinder lock, to fluid-lock the cylinder at any degree of extension immediately upon release of hydraulic pressure from the lines. This lock will allow the landing gear to extend but will prevent its retraction until fluid pressure is applied to the retracting side of the cylinder. The emergency air valve and the hydraulic lock are secured as a unit to the exterior of the cylinder and are interconnected with brazed steel lines. The landing gear cylinder air valve and hydraulic lock are similar to those of the wing flap cylinder in both construction and operation.

Wing Flap Cylinder

The wing flap cylinder shown at figs. 6 and 7 is of advanced design and obviously a product of large scale production; as forgings, pressure stampings and screw-machine parts are used throughout.

The aluminum alloy cylinder barrel is machined from a forging requiring the minimum of finishing operations. Additional machine operations, weight and the possibility of leakage are reduced by the mounting end-cap and barrel being integral. The piston rod and piston head are forged and machined in one piece. Two soft synthetic rubber packing rings of large cross section, and two retainer nuts complete the simple piston assembly. Internal threads and packing seat is provided at the open end of the barrel to accommodate the end-cap, which contains the cup-type piston rod packing and its retainer nut. The seals and end cap are secured by snap rings.

Self-aligning, spherical, two-piece bearings are provided for mounting the cylinder. A shuttle-valve unit is attached to the cylinder, the function of which is to fluid-lock the flaps at any desired position by preventing the return flow of fluid from either cylinder port.

From a study of the diagram at fig. 5 it will be seen that check valves permit the flow of fluid to, but prevent flow from, the flap cylinder. Due to the incompressibility of fluid it becomes necessary to unseat the check valves before there can be motion of the cylinder. This is accomplished by applying fluid pressure to the desired port on the system side of the shuttle-valve. As fluid enters the valve a spring loaded piston unseats the check valve on the unloading side of the flap cylinder while fluid freely passes through the other check valve and into the cylinder. Retaining washers prevent balancing action between the shuttle-valve piston loading-springs. Close tolerances avoid use of seals on the piston. This lock permits the pilot to extend and lock the flaps at any desired position by manipulation of the selector valve; with a position indicator being provided.

Selector Valves

The piston-type selector valves used for the control of the Messerschmitt hydraulic system shown at figs. 8 and 9, are similar in size and appearance to American valves, but radically different in design and construction.

These valves are the automatic neutral, open-center or continuous flow, type, and are connected in series as shown at fig. 9. Two control knobs project through the instrument panel from each valve; one for extending, and the other for retracting the actuating cylinders.

With all valves in neutral position, the fluid freely passes through the valves and returns to the reservoir, with only a slight back-pressure in the system; with the fluid in the actuating cylinders being checked by the shuttle-valve hydraulic locks.

To operate the landing gear or flaps the desired knob is pressed, and the fluid is then directed to the affected cylinder. The knob remains depressed until the cylinder stroke is completed, at which time it automatically returns to neutral position.

The pilot can stop the actuating cylinder's movement at any desired point by manually returning the related control knob to neutral position. Depressing both extending knobs or both retracting knobs will cause the landing gear and flaps to operate in sequence; with the landing gear extending or retracting its full travel before flaps movement occurs.

A valve housing machined from magnesium alloy bar-stock is drilled and reamed to contain the two piston valves and their return mechanism. No bearings or inserts are pressed into the housing, as all bearing areas and ports being machined directly into the body. All moving parts are of steel while the caps and retainer plugs are machined from magnesium alloy. Internal porting was accomplished by drilling from the outside; soft plugs were then driven and ring-staked where necessary for sealing. No internal seals are employed except at the piston rod retainer nuts and on the return valve body.

A study of the flow diagram at fig. 9 will show that fluid is by-passing through the landing gear valve to the flap valve, which is set to extend the flaps. The landing gear valve is in neutral position, and the flap cylinder has just completed its travel, causing the automatic-neutral mechanism to function.

The small check-valve in the body of the return valve permits the necessary fluid displacement as the valve pistons are moved within the valve body when operating the selector valves. The fluid trapped behind the pistons passes through the check valve and enters the return line to the reservoir.

Brakes

Conventional hydraulically-operated expanding-shoe type brakes are used, with two brake assemblies being installed within each wheel. The brakes being on either side of the wheels requires the disassembly of the brake lines, when a wheel is removed. Brakes shoes are approximately 1-3/4 in. wide x 10-3/4 in. dia.

Master Brake Cylinder Units

Master cylinder units are manually-operated by toe pressure on the rudder pedals. Each cylinder is of approximately 1-1/4 in. dia., with a stroke of 1-3/4 in.. Provision is made to renew the brake fluid in the system from a single, separate brake-fluid reservoir, which connects to both brake units.

HYDRAULIC EQUIPMENT

SECTION III CHAPTER 2

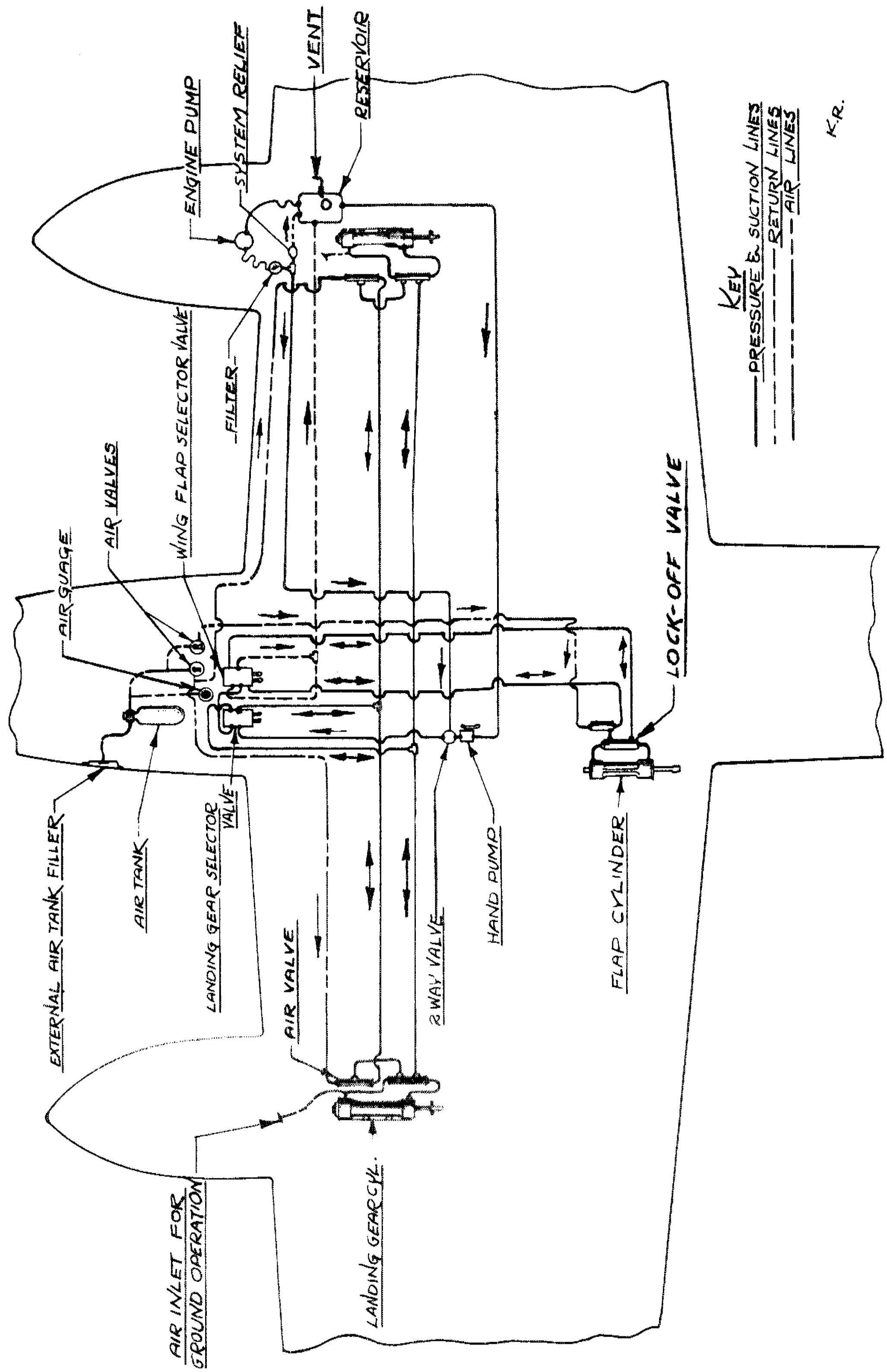


FIG. 1 HYDRAULIC SYSTEM DIAGRAM FIG. 1

HYDRAULIC EQUIPMENT

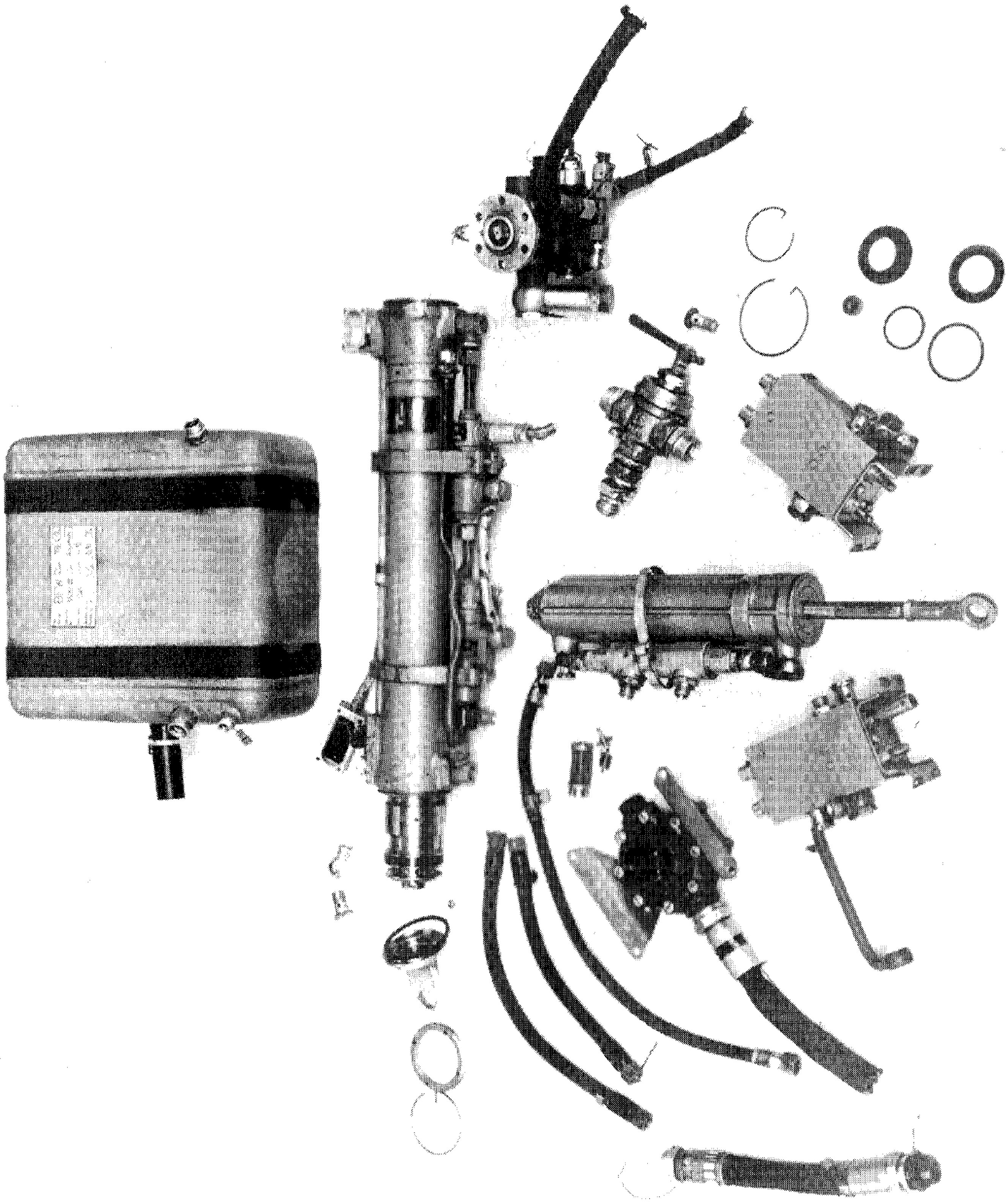


FIG. 2 HYDRAULIC SYSTEM UNITS FIG. 2

HYDRAULIC EQUIPMENT

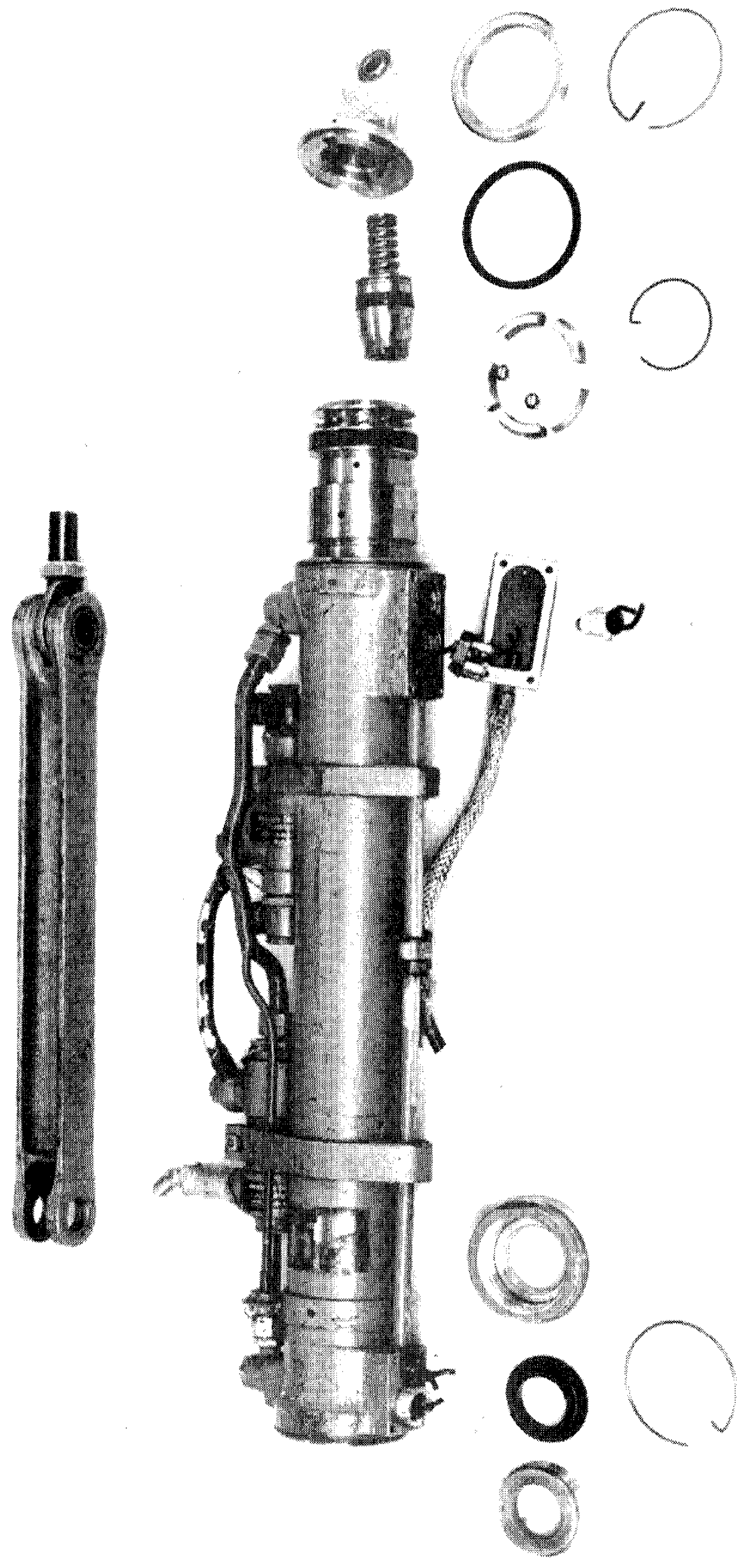


FIG.3 LANDING GEAR ACTUATING CYLINDER FIG.3

HYDRAULIC EQUIPMENT

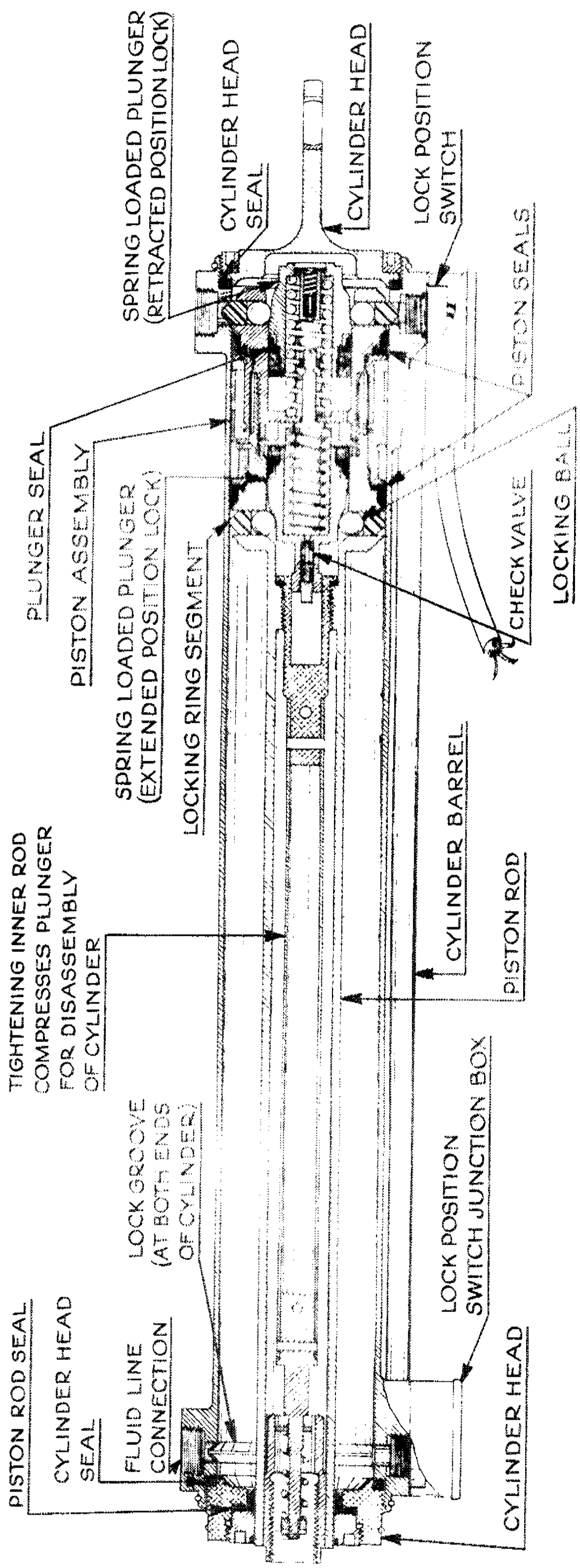
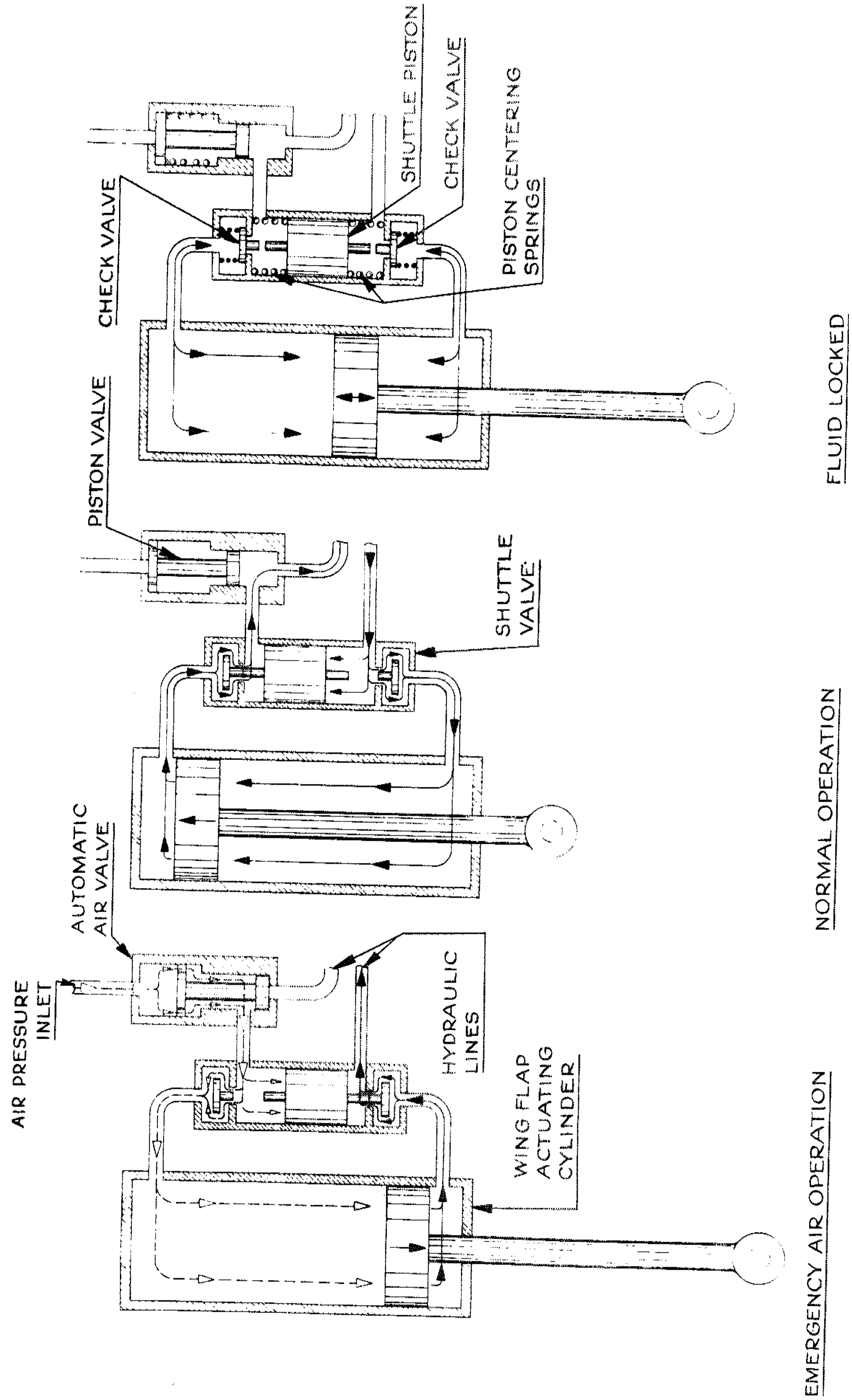


FIG. 4

LANDING GEAR ACTUATING CYLINDER CROSS-SECTION

FIG 4

HYDRAULIC EQUIPMENT



FLAP ACTUATING CYLINDER FLOW DIAGRAM

FIG. 5

FIG. 5

HYDRAULIC EQUIPMENT

SECTION III CHAPTER 2

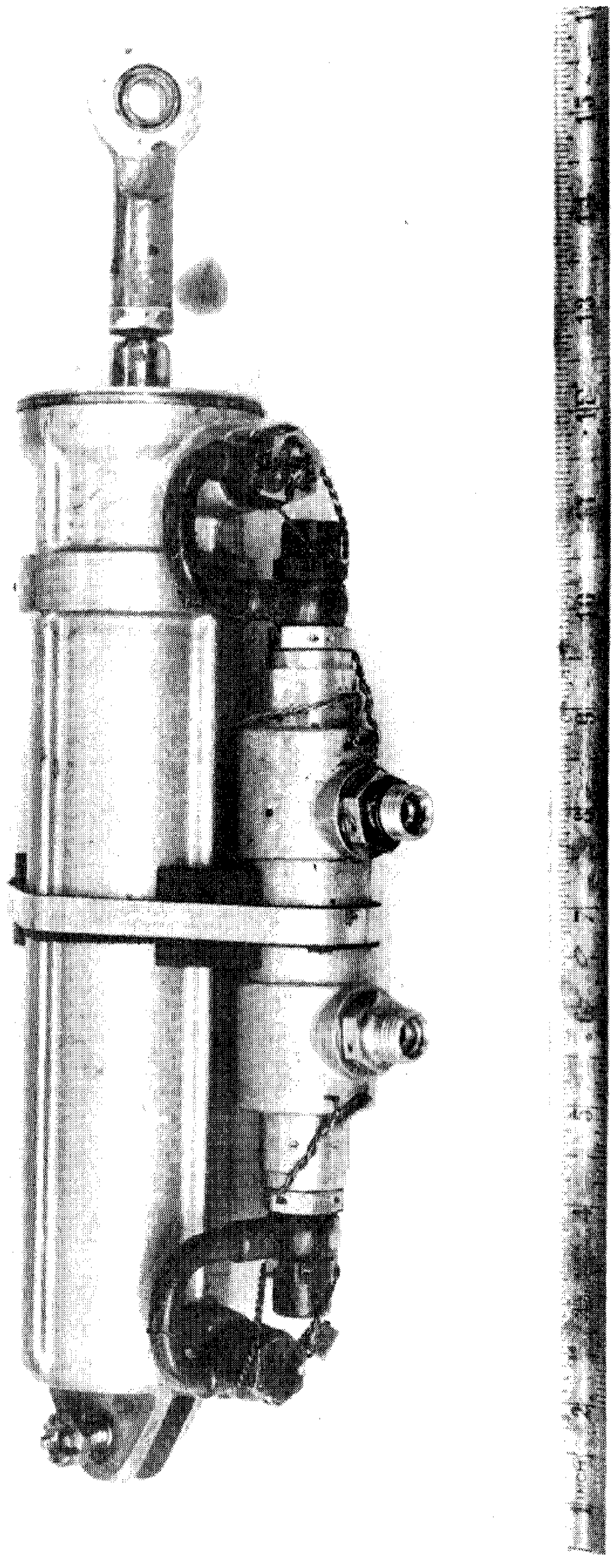


FIG. 6 FLAP ACTUATING CYLINDER FIG. 6

HYDRAULIC EQUIPMENT

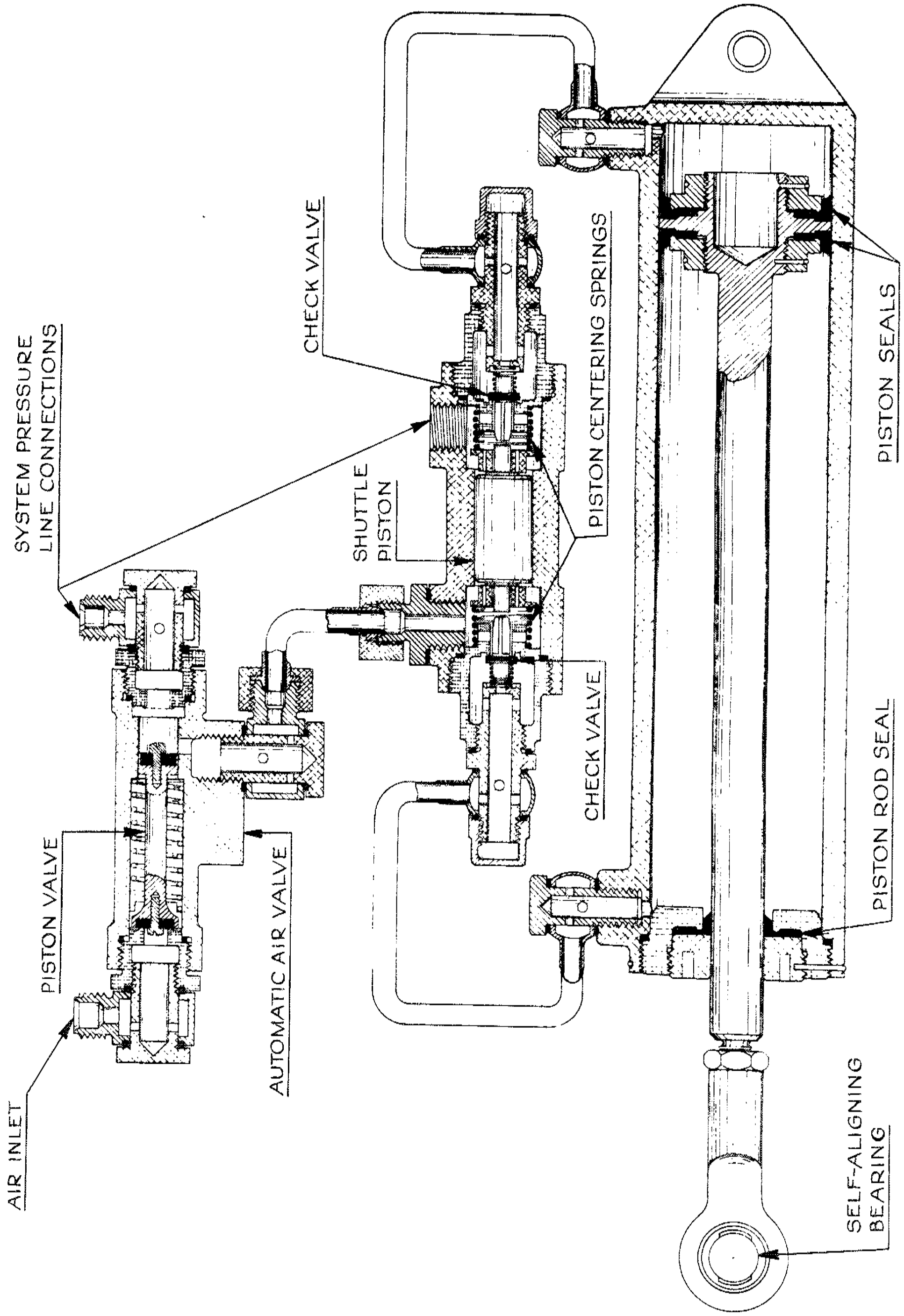


FIG. 7 FLAP ACTUATING CYLINDER CROSS-SECTION FIG. 7

HYDRUALIC EQUIPMENT

SECTION III CHAPTER 2

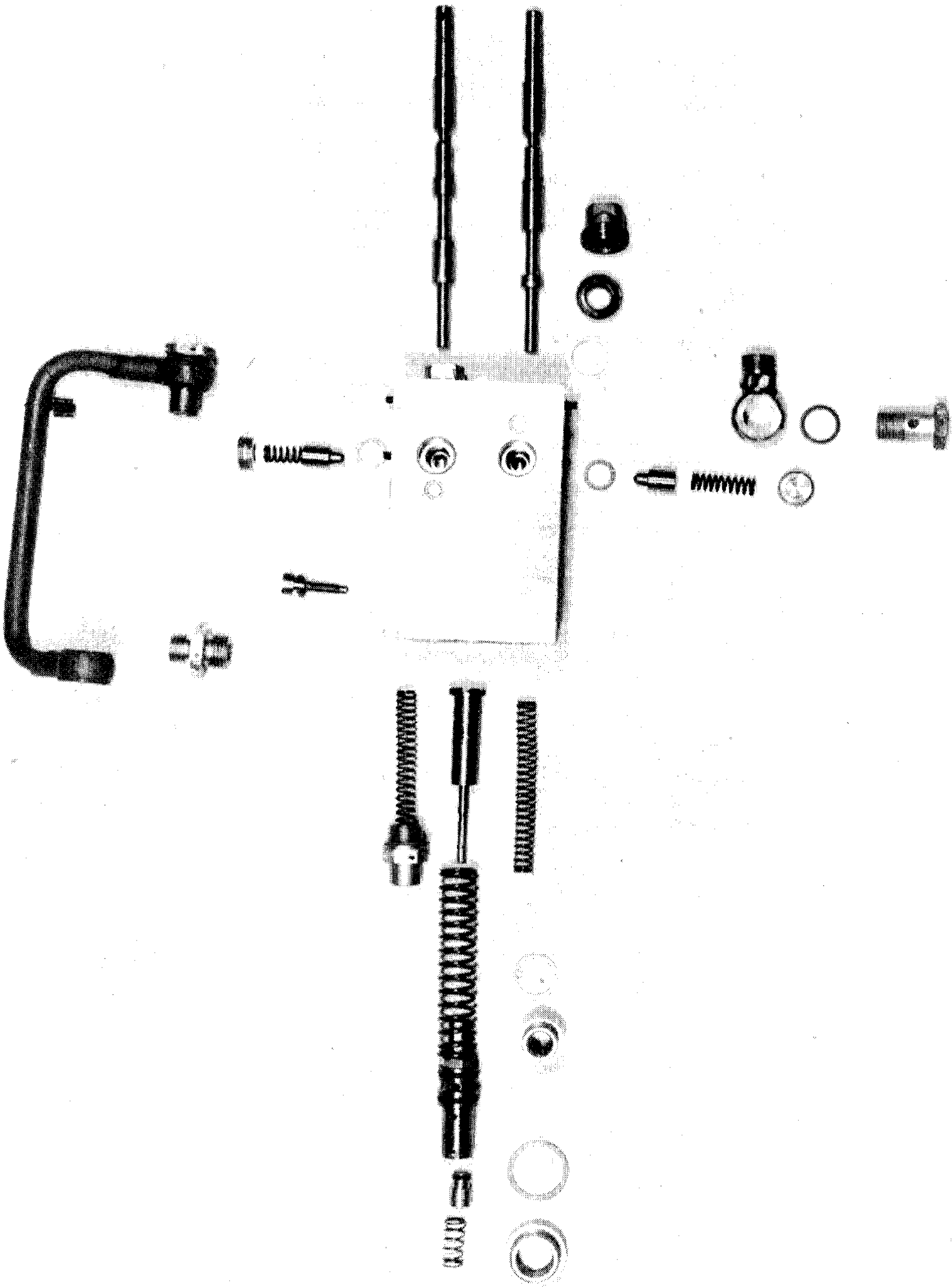


FIG. 8 HYDRUALIC SELECTOR VALVE FIG. 8

HYDRAULIC EQUIPMENT

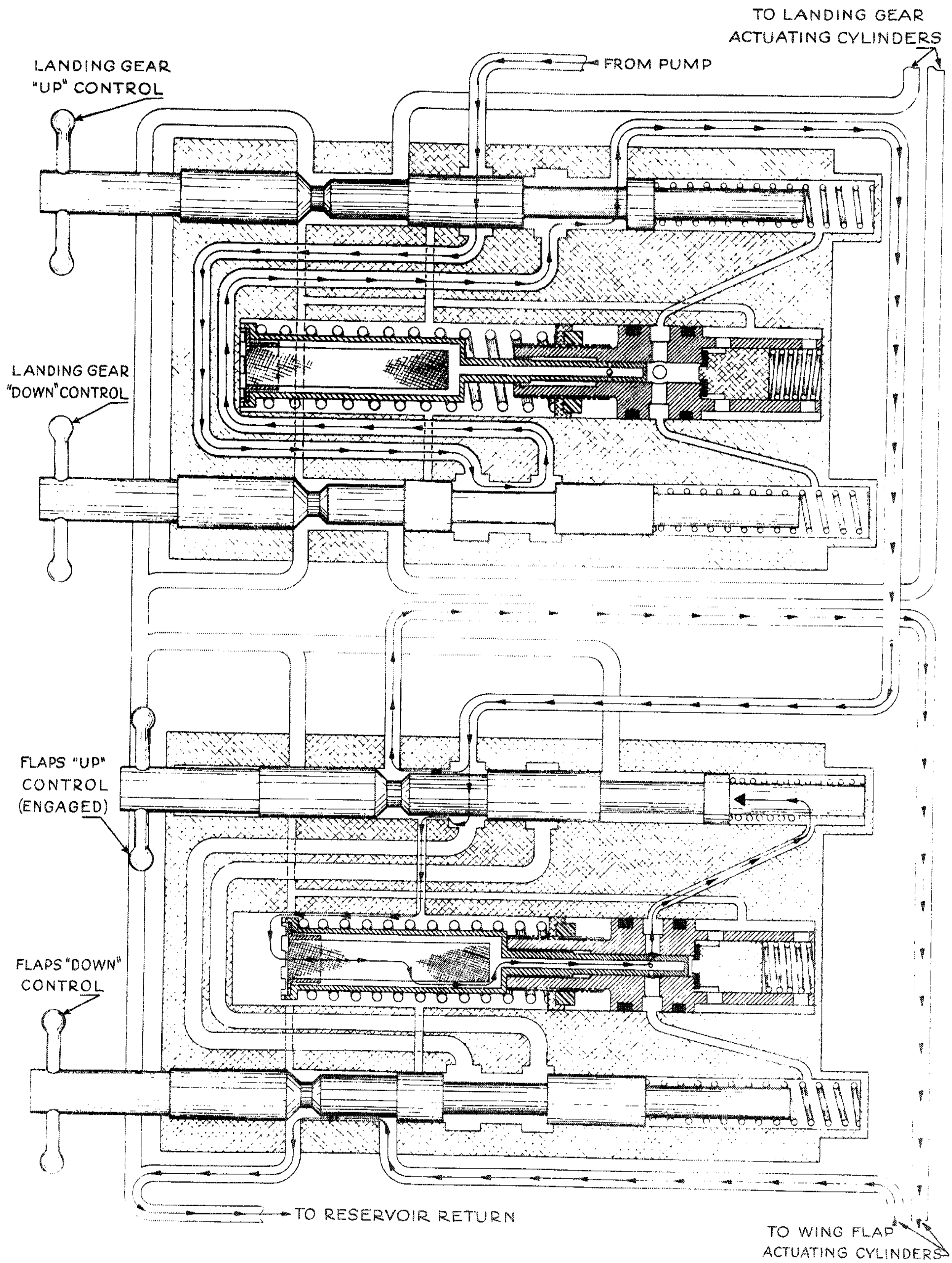


FIG. 9 HYDRAULIC SELECTOR VALVES FIG. 9

Chapter 3

ELECTRICAL EQUIPMENT

Chapter 3

ELECTRICAL EQUIPMENT

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SECTION III

Chapter 3

ELECTRICAL EQUIPMENT

The electrical system of the Messerschmitt Me110 follows European convention by being a 24-volt ungrounded type, with one battery and two engine-driven generators as the primary power sources. Rigid conduit is used in the airplane only where necessary for installation of wiring in inaccessible places, and the only adequately shielded circuits are the radio and ignition wiring.

Wiring

The wiring in the electrical circuits is mainly single conductor with several wrappings of a dark-colored plastic tape and a varnished cambric covering. Over this is a closely woven aluminum-braid. In contrast to American practice, which is to connect the extremities of this outer braid to the grounded shielding of the items connected to the wire, the braid on the wiring is terminated approximately a half inch from the end of the wire and is left electrically ungrounded except for incidental bonding by the mounting clips. The ends of the braid are served by a wrapped aluminum sleeve, stamped with the wire number. This wire number is composed of a letter and numeral, with the letter designating the wire's functional circuit; such as the starter and ignition wires belonging to the "[illegible]" circuit, and all propeller pitch control wires being the "E" circuit. Numbers begin with 1 for the wires of each functional circuit.

Some circuits (such as coolant radiator shutter and propeller pitch controls) require many wires, each conducting relatively small currents, and thus are well adapted to multi-wire cables. The cables used for these circuits are

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. H. A. Gibb, Staff Engineer in Charge of Electrical and Radio Design for the Engineering and Development Dept. of Vultee Aircraft, Inc.

standard types, comprising color-coded rubber-jacketed wires contained within a rubber sheath wrapped with varnished cambric, and a cover of aluminum braid. Terminal numbers are affixed to the wire ends. Cable standardization is achieved by minimizing the variety of cables used, and several circuits employing a multi-conductor cable use only a portion of the wires. The unused wires of the cable are terminated with insulating sleeves.

Cable Installation

Cables and wires are installed to the airplane structure by a form of clamp that permits them to be first assembled in the proper mechanical arrangement, and then banded into position against a back-plate clipped to the structure. These clamps are installed at intervals of approximately eight inches. This method allows the electrical cables to be prefabricated and banded to their back-plates as a bench operation. At the same time the wire terminals are installed by stripping the insulation and crimping a thin tinned copper sleeve to each wire end. This sleeve secures the wire end, and makes a suitable connection for the compression-type terminals used in the electrical apparatus.

It can be assumed that all electrical cables are installed in the airplane by placing the cable groups in their proper positions, sliding the back-plates into mating hangar brackets riveted to the airplane structure, and then staking the back-plates in place. The entire installation within the cockpits is protected with covers secured by spring clips. All the electrical wiring is routed along the right side of the fuselage, and radio wiring is on the left side. Approximately 30% of the available side area of the fuselage is used for wiring installation.

Cross-Connection Terminal Panels

This installation would require that all wires and cables run parallel without crossing between junction blocks or equipment, were it not for the cross-connection terminal panels provided. These panels are provided with terminals on one side and cross-connection wiring on the opposite side, and make possible leading wires to the panel in one order and leading them away grouped in a different order. Many parallel connected terminals are necessary on these panels, as only a single wire is connected to a terminal. These terminal panels are constructed as a complete assembly; and are not shielded, either as an assembly or upon installation. Compression type terminals are used on all panels. In fact, there are no soldered connections at any terminal in the electrical installation in this airplane, although many of the permanent external connections within units are soldered.

Wire Sizes

A majority of the wires in the airplane are of smaller gauge than used by American airplanes for circuits carrying similar loads, and this difference approximates 2 B & S gauge sizes. In multi-conductor cable, wires as small as #22 B & S are used. These wires, however, are used in low-current circuits such as indicator lights or relays, and are given mechanical strength by being part of a cable assembly.

Circuit Breakers

Protection is afforded the electrical system components by circuit breakers of the manual-set, manual-release, thermal-type, with separate buttons for set and release. These breakers essentially comprise standard operating-assembly and thermal bi-metallic release mechanism, with the contacts standarized at the breaker's maxium rating of 75 amperes. Provisions are made for shunt strips to increase the breaker's current capacity. One of these breakers, which serves as a battery disconnect switch, is equipped with an auxillary magnetic release for remote operation from the pilot's cockpit, and with a manually operated reset pull-wire from the pilot's cockpit. All circuit breakers are unshielded, and no provision is made for grounding of the shielded cable ends.

The degree of protection afforded some circuits by these breakers is dubious, as several unprotected branch circuits with small wires of current capacities less than the associated breaker lead off from the larger wire. In other cases of circuit division, such as the armament circuits, each circuit is protected with a fuse mounted in an extractor-type holder.

Circuit Connections

Plug and receptacle connectors are used wherever connection must be made to a removable unit. These plugs are similar to conventional American units except that wires are connected to terminals by screw-type connectors rather than solder. A simplified method of joining plug and receptacle is provided by a spring bail, rather than the American practice of threaded flange and coupling nut. Rubber gaskets and sleeve-seals are used on all connector plugs.

Connection between wing and fuselage are made with a unique blade-and-clip device, which in principle is identical with a multi-pole knife-switch. Each wire from the fuselage connects to a hook-like terminal clip made up of two cupped halves open along the plane of the hook. The wing wiring connects to a mating hook-shaped blade designed to slip into the open portion of the fuselage clip. Large wires are connected to large terminals and small wires are connected to small terminals and the whole are grouped on an insulated through-bolt passing through the terminal hook openings, with insulating strips providing electrical separation of the terminals. When the two parts are mated, the bolt is tightened and the clips securely grip the blade-ends. This affords a firm connection without the expense of special plugs and receptacles, as any combination of connectors may be assembled to fit the specific application. A few isolated plugs are used at the wing junction but the majority of the connections are made through the clip-and-blade connector assembly.

In many cases it is impossible to keep two or more pieces of flexible cable from chafing. When this condition exists each piece of cable is covered with a perforated synthetic rubber sleeve, and the cables lashed together.

Radio Interference

High frequency filters are used to prevent radio interference from the airplane's unshielded wiring. These take whatever form the particular interference-creating device may require, being simple by-pass condensers in some cases, while other circuits require condenser-coil combinations in various types of low-pass filters. In general, these filters are built directly into the offending piece of equipment. Some of the electrical components were originally designed with grounding terminals for shielded cables, and these are used wherever convenient, while in other cases the shielding connections are not used.

Electrical System Controls

Control of the electrical system is divided between the pilot and gunner. This procedure seems a little [illegible], for there is interphone connection only between pilot and navigator, and no apparent way for the pilot to communicate his desires to the gunner. In general, the pilot has command of the circuits for: (1) fuel pumps; (2) fuel [illegible]; (3) starter; (4) ignition; (5) battery disconnect; (6) armament; (7) instrument lights; (8) landing light; and (9) coolant radiator shutters. The gunner's electrical panel provides circuit breakers for generator control, radio, and the balance of the electrical system. The generator charging switch is located on this panel. Lighting for the rear cockpit is furnished by extension cord lamp, normally stowed on a spring-loaded reel.

Ignition and Starting System

The ignition and starting system of the Me110 is unique in respect to both operation and mechanical design. The circuit is arranged to prevent accidental operation of the engine starting system when the magneto disconnectors at the wing are open.

To start an engine the ignition switch must be turned to "Both" and the starter handle then operated in the conventional manner. The electrical operation of this circuit is such that the battery is connected through the starter and ignition switches to supply voltage to the magneto primary windings through the booster vibrators, and thus boost the magnetos.

The starter is a conventional hand-electric inertia type, with its major difference from American types being that the armature remains engaged during hand-cranking. This is accomplished by lifting the brushes off the commutator with a manual control, thereby reducing drag and permitting use of the armature for additional flywheel effect. American starters disengage the armature from the inertial flywheel, thereby losing some kinetic-energy storage.

Magnetos

Each engine is equipped with one dual magneto having internal structure and circuits comprising the functions of two separate magnetos. Each coil has its own magnetic circuit with only the rotor and permanent magnets being common. Two sets of breaker points are provided for each coil, minimumizing the danger of failure through defective breaker points, and each coil has its own condensor and distributor.

The structure of the magneto rotor causes the magnetic field to have a complete reversal instead of a build-up and collapse as is customary in American magnetos. This design feature should result in a marked increase in life of primary breaker points due to the fact that there is a reversal of polarity for each alternate opening of the points.

Connection for boosting and ignition switch circuits are carried from the magneto directly to the ignition switch by auxiliary wires, to prevent a high-resistance ground connection from affecting the operation of the magneto, although the magneto switch circuit is actually grounded to engine and airplane structure.

Generators

A generator is provided on each engine. These generators are controlled by individual voltage regulators which are interconnected to give load equalization control.

Operation of the two generators in parallel is made possible through the type of voltage regulator used. The circuits of these is shown at fig. 3, wherein coil "A" is the shunt or voltage coil which closes contacts "1" when the generator comes up to charging voltage. Coil "B" is a series coil and operates as a combination reverse current and overload coil. On reverse current, "B" opposes "A" opening contacts "1" while on overload "B" and "A" are additive, operating the second armature and contacts "2", which inserts a series field resistor "F" in the circuit to reduce the generator output. Coil "D" is an over-voltage or voltage regulator coil which opens contacts "3" to again insert the resistor "F" in the field and reduce the output voltage.

Coil "C" is the equalizing coil serving to keep the load divided equally between the two generators. If the voltage of the one generator shown becomes higher than its associated generator, current will flow through coil "C" which is connected in series with coil "C" in the regulator of the other machine. The pull of coils "C" and "D" in the one regulator will add and open contacts "3" to insert resistance "F" in the field circuit and reduce the generator output. In the other regulator, coils "C" and "D" will cancel and the output of the associated generator will remain unchanged.

Resistance "E" is a series resistance for voltage coils "A" and "C", and does not enter actively into the operation of the unit.

Output of both generators are paralleled through a common thermal circuit breaker to the busbar. The ammeter is connected between the busbar and the battery.

Battery

The battery is installed on a mounting located well aft in the fuselage, with a large access door in each side of the fuselage at this location. The battery mounting also serves as a support for the three radio dynamators. A battery cart receptacle is provided aft of the right-side wing trailing-edge.

Main distribution of the electrical system is at the switch panel in the gunner's cockpit. All connections made to this panel connect to terminal blocks made with dual-screw type terminals of several sizes to accommodate various size wires. These are assembled in a long group with insulating separators between individual terminals except in the case of those terminals which have a common connection inside the distribution panel, which are fastened directly together without insulation. The whole distribution panel is assembled and wired as a unit, and then installed in the airplane without shielding provisions.

Propeller Control

Electric control of the adjustable pitch propellor is accomplished by an electric motor mounted on the crankcase of the affected engine. Position of the blades is recorded by a remote pitch indicating instrument of the conventional step-repeater type. The equipment associated with the propeller was too badly damaged to permit a satisfactory analysis. It is possible that automatic propeller-pitch control and automatic synchronization, were provided.

Electric Instruments

An electric tachometer is provided for each engine. The accuracy of these instruments has been reported as very good.

Direct-current Selsyn fuel gauges with a vertical-moving float are used. A four-position selector switch is used to connect the indicator to the desired tank. The indicator has two scales, one for forward tanks and another for aft tanks. Low fuel-level warning-lights, one for each of the four tanks, are provided. Their operation is independent of the setting of the gauge-selector switch to preclude the possibility of consuming all the fuel from a tank without warning, due to the gauge being connected to a different tank. A fuel-pressure warning signal is not provided.

The landing gear and flap position indicating system comprises warning lamps for the gear and a mechanical position indicator for the flaps. Lamps are provided to indicate either full-up or full-down position of each gear, and a conventional warning horn is incorporated. Indicating switches are an integral part of the main landing-gear hydraulic-actuating cylinders.

Coolant Radiator Shutters

Each coolant radiator shutter is operated by a 9-point rotary selector switch in the pilot's cockpit. The motor unit at the shutter is a compound-wound motor incorporating provision for dynamic braking, with reduction gear box, control relay, position-control switches and interference filter.

The motor will operate to the position of the selector switch and then stop. Overrunning the position switches entirely with consequent damage to the associated equipment is prevented by a master limit-switch which operates upon overtravel in either direction. The operation of the motor can best be understood by inspecting the circuit diagram at fig. 9.

Lighting Equipment

One fixed landing lamp is provided in the left wing leading edge. Standard navigation lamps are installed on each wing-tip and on the tail cone. The electrically heated pitot head is installed on the right hand wing. No recognition or signal lamps are in evidence.

Cockpit lighting is handled by two lamps mounted under the edge of the fuselage deck directly in front of the pilot.. The navigator's cockpit (where the radio equipment is located) has no provision for a lamp but the gunner's cockpit has a lamp on a retractible cord normally reeled-up for stowage.

Armament

The armament electrical system is quite different from conventionsl American practice. Circuit details are shown in figure F, which should be refered to while studying the following circuit.

The armament circuits and gun sight light are connected to the ship's electrical system through a circuit breaker. The cannon firing, gun firing, and charging control circuits are energized through a master switch on the gun-charging control panel, located on the instrument panel in front of the pilot.

When the master-switch is closed, pressing any of the four push-buttons on the gun-charging control panel, operates the solenoid valve on the charger of the associated gun, opening the breech. When the breech mechanism locks open a set of contacts are closed operating a light on the gun-charging control panel which indicates that the gun is charged and ready to fire.

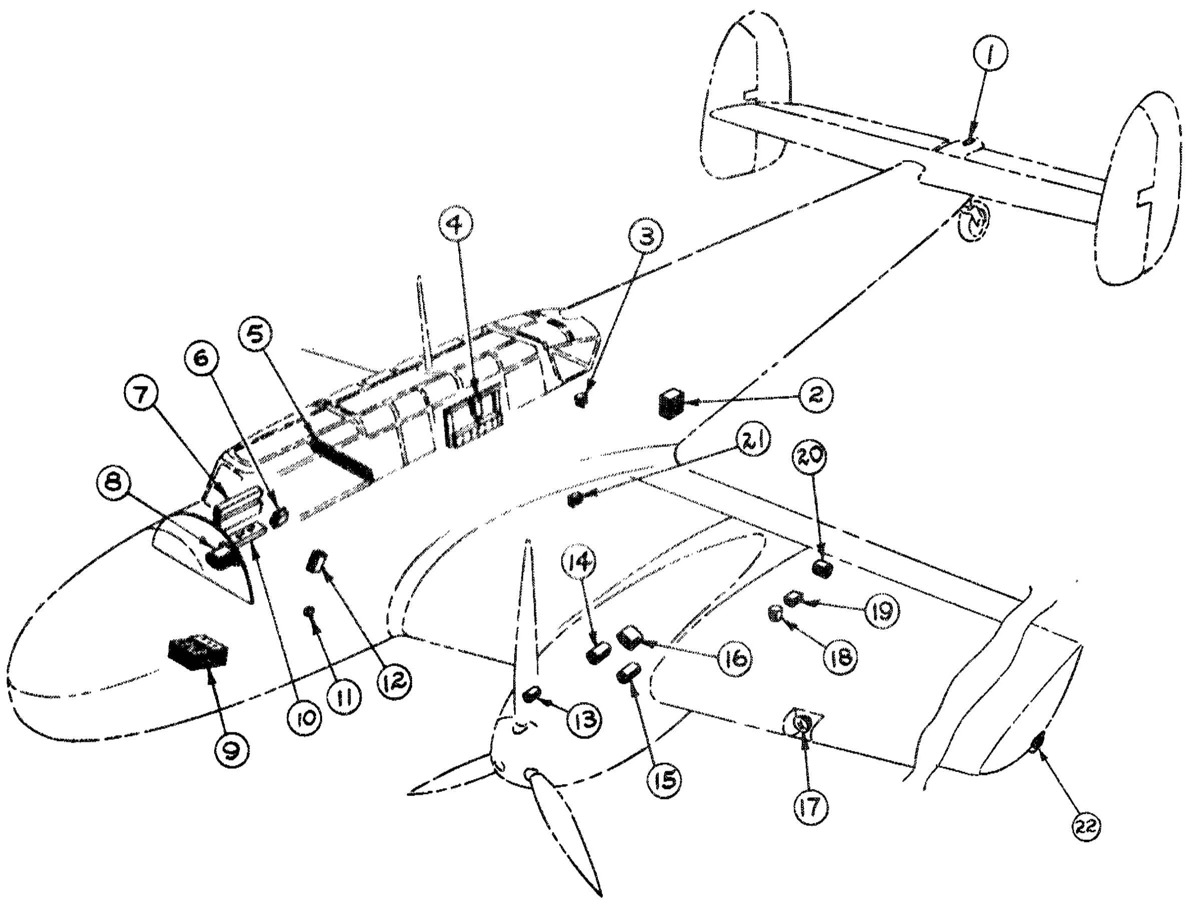
Squeezing the trigger on the control stick operates simultaneously the breech closing relay and the gun firing relay. The breech closing relay operates a solenoid valve on each gun charger, releasing the latch which holds the breech open. (The gun camera is also operated by this breech-closing relay.) When the breech closes the gun fires, the firing mechanism having been operated by the firing solenoid which was energized by the firing relay.

This type of firing cycle gives rise to the possibility of having the gun stop firing with the breech closed, the result of releasing the trigger after the breech has started to close. To prevent this, the firing relay is of the time delay type, having a lag of approximately one to one and one half seconds, therefore the firing mechanism of the gun is sure to be energized whenever the breech closes and the gun will fire the last charge, opening the breech and leaving the gun in a ready condition.

The cannon firing circuit is entirely conventional with individual relays and fuses for each cannon, controlled by a dual-control push-button on top of the control stick.

Electrical Equipment

SECTION III CHAPTER 3



1 TAIL LIGHT

2 BATTERY

3 REMOTELY CONTROLLED MASTER SWITCH

4 MAIN ELECTRICAL DISTRIBUTION SWITCHING PANEL

5 RADIO OPERATOR-NAVIGATOR'S INSTRUMENT PANEL

6 STARTER SWITCHES

7 JUNCTION STRIPS

8 ARMAMENT CONTROL UNIT

9 ARMAMENT RELAY BOX

10 PILOT'S SWITCH PANEL

11 HORN

12 IGNITION SWITCHES

13 PROPELLOR PITCH CONTROL MOTOR

14 STARTER

15 GENERATOR

16 MAGNETO

17 LANDING LIGHT

18 GENERATOR FILTER--LEFT HAND ENGINE

19 GENERATOR CONTROL--LEFT HAND ENGINE

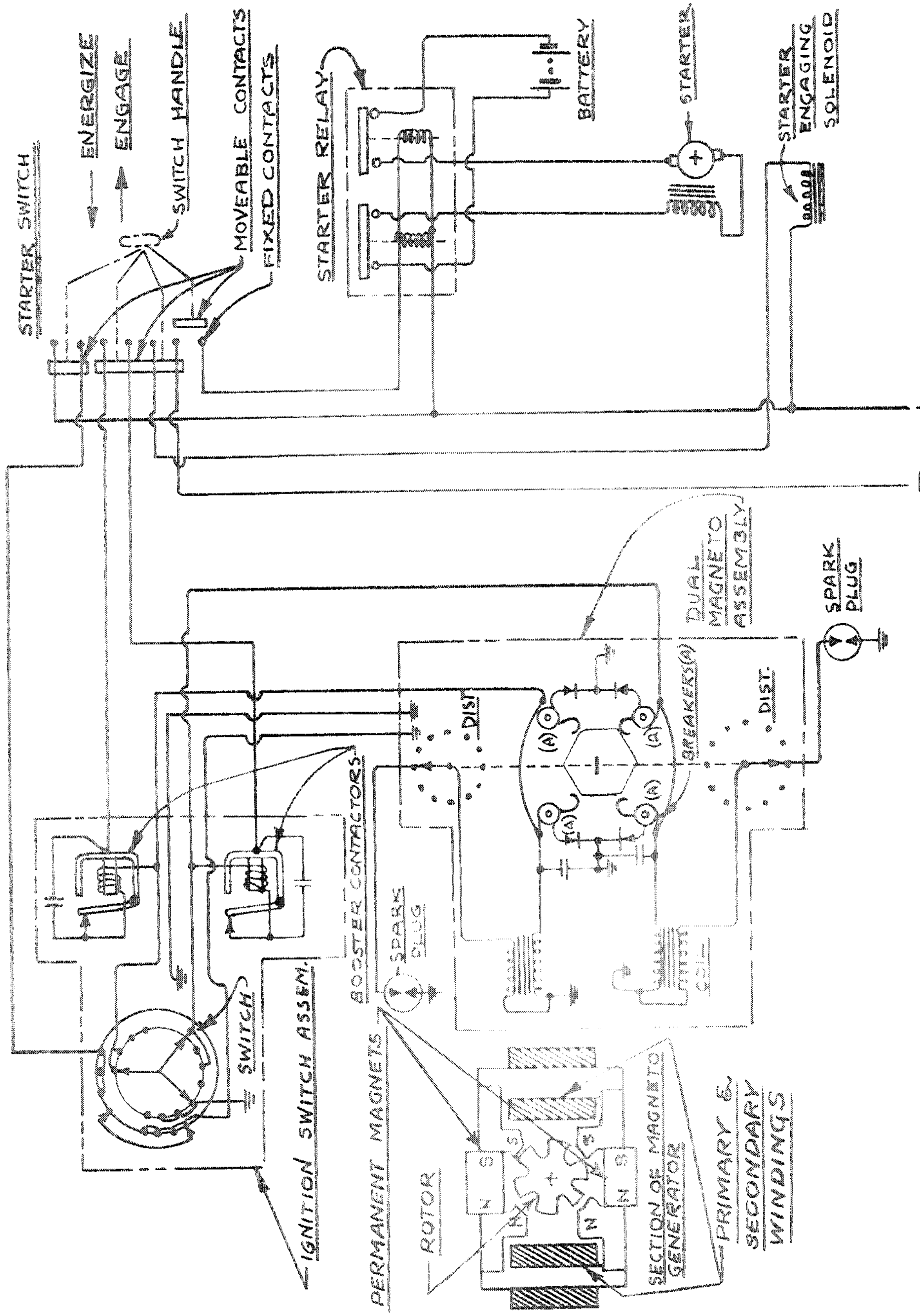
20 COOLANT FLAP OPERATING MOTOR

21 STARTER RELAY--LEFT HAND ENGINE

22 NAVIGATION LIGHT

FIG. 1 ELECTRICAL EQUIPMENT LOCATION DIAGRAM FIG. 1

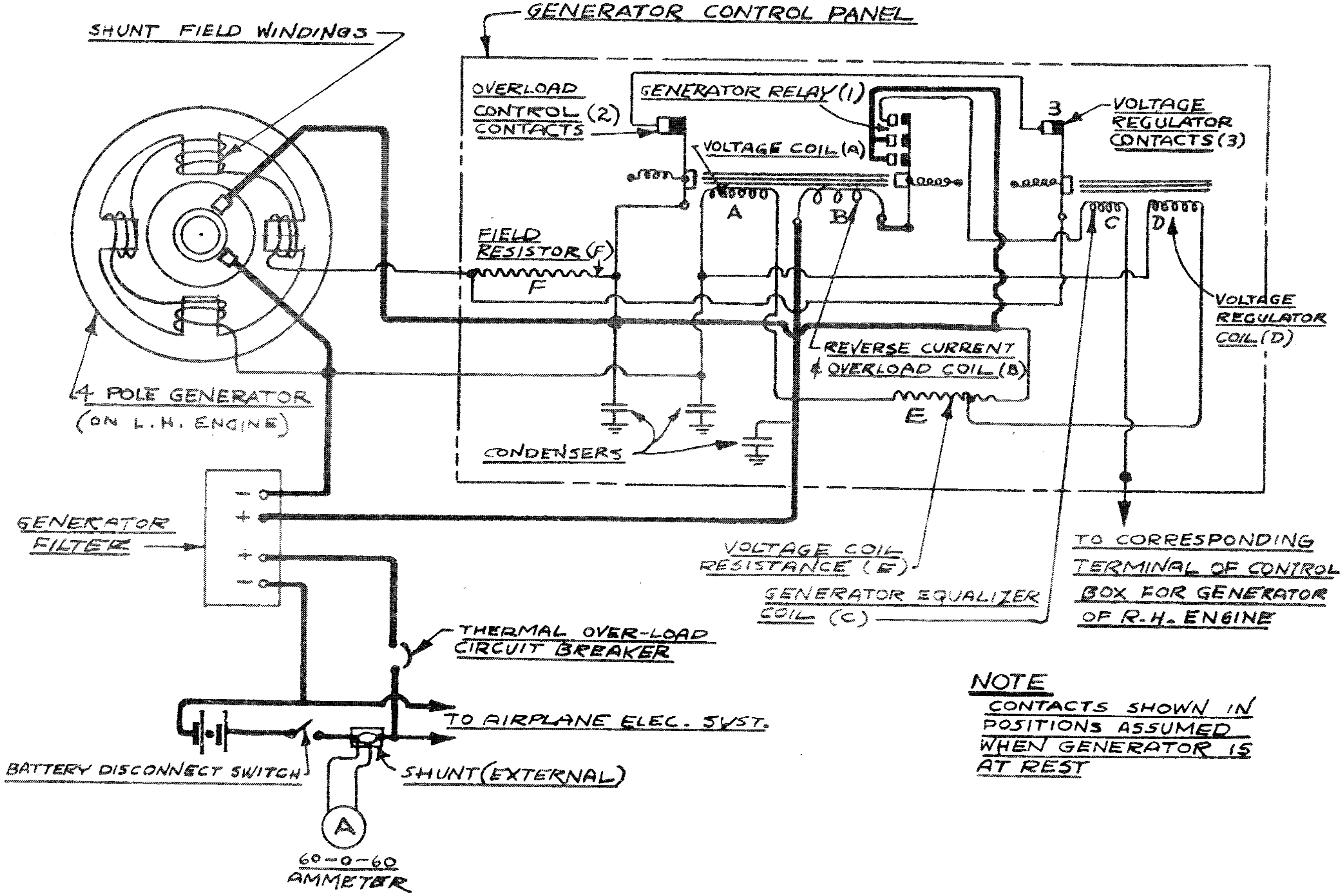
ELECTRICAL EQUIPMENT



STARTER & IGNITION SYSTEM

CIRCUIT DIAGRAM

FIG. 2 FIG. 2



NOTE
CONTACTS SHOWN IN POSITIONS ASSUMED WHEN GENERATOR IS AT REST

FIG.3 GENERATOR CIRCUIT DIAGRAM FIG.3

ELECTRICAL EQUIPMENT

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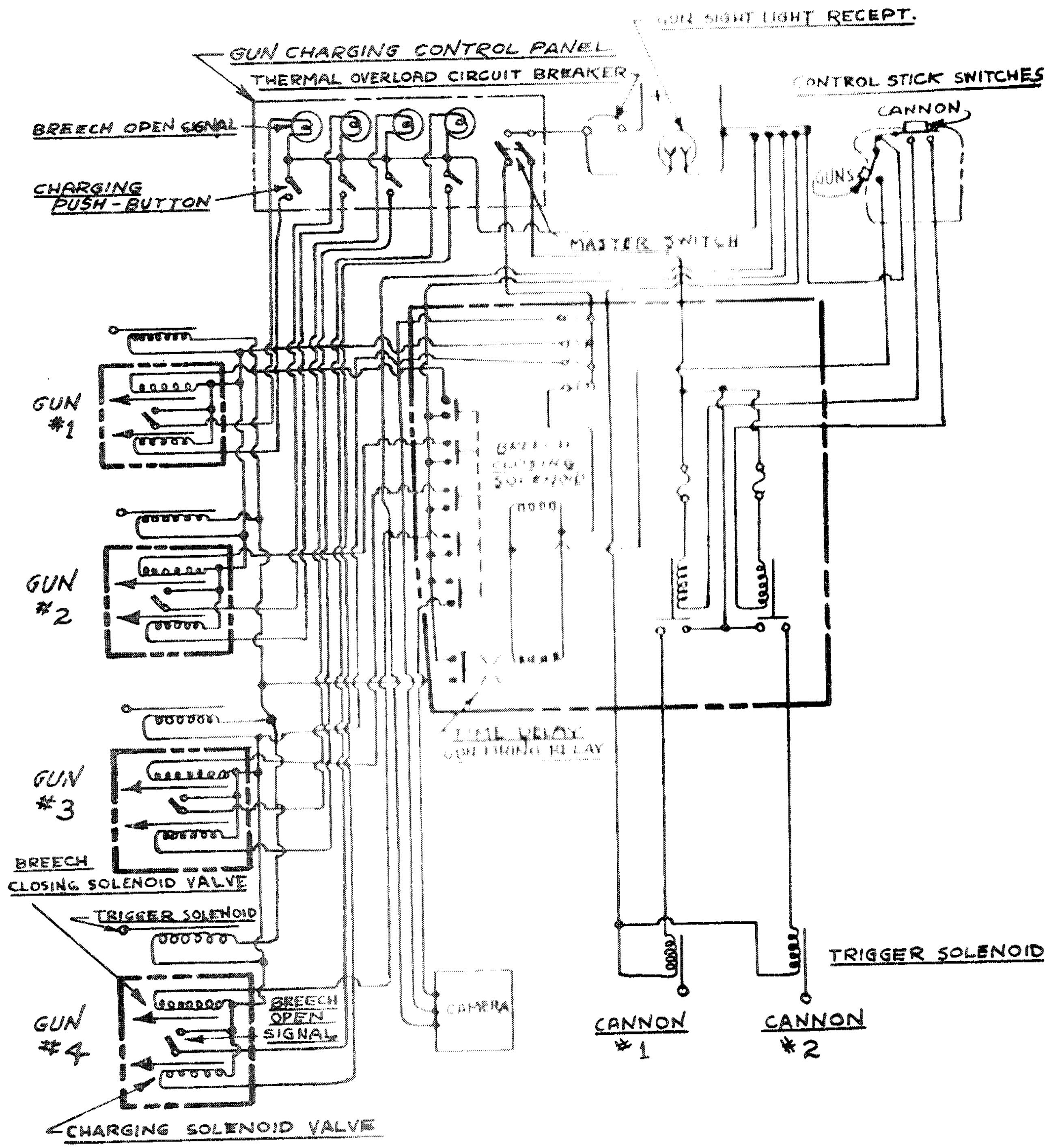
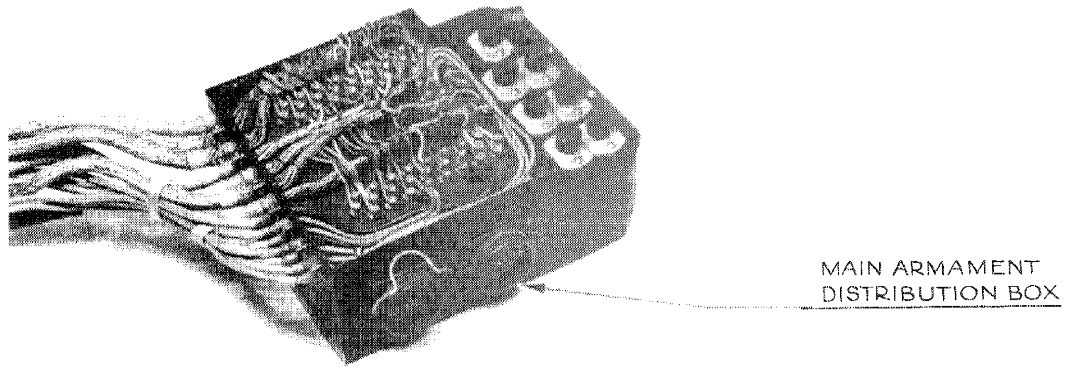


FIG. 4 ARMAMENT CIRCUIT DIAGRAM FIG. 4



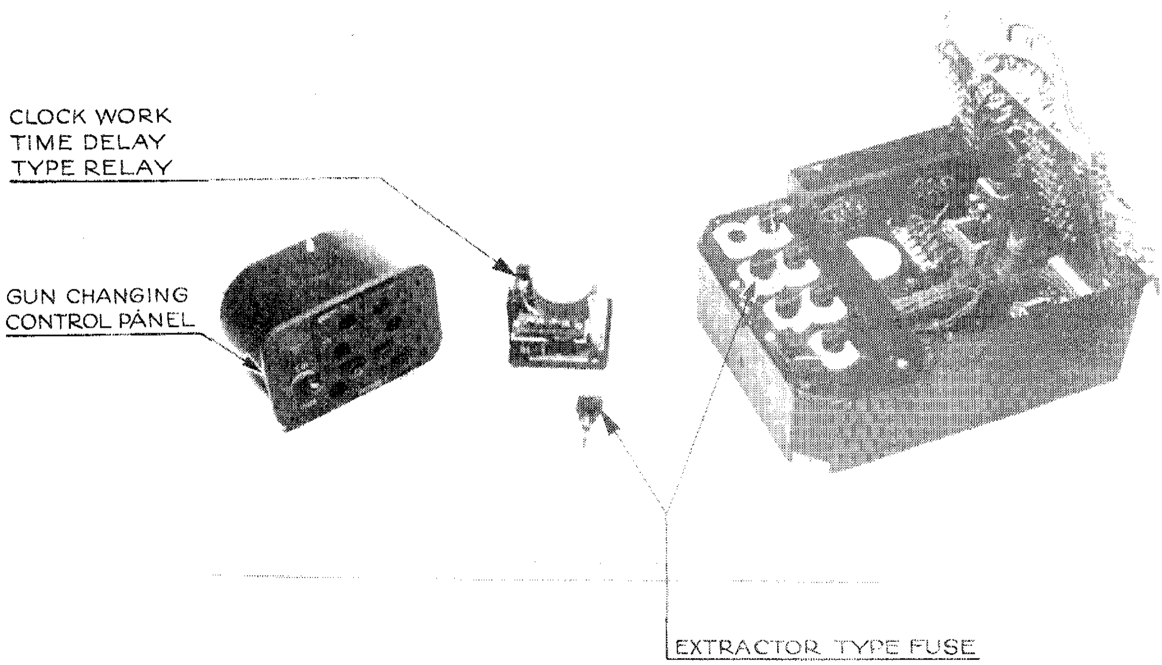
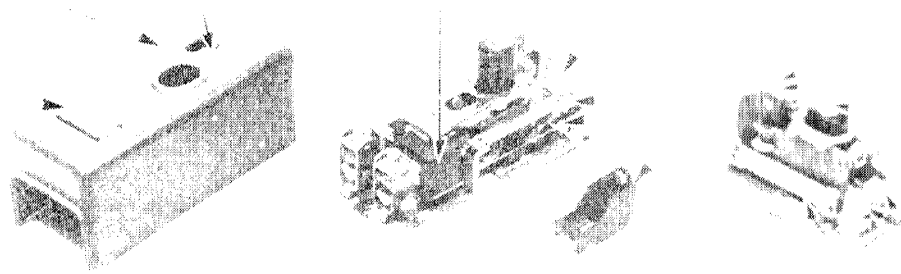


FIG. 5 ARMAMENT ELECTRICAL CONTROLS FIG. 5

ELECTRICAL EQUIPMENT



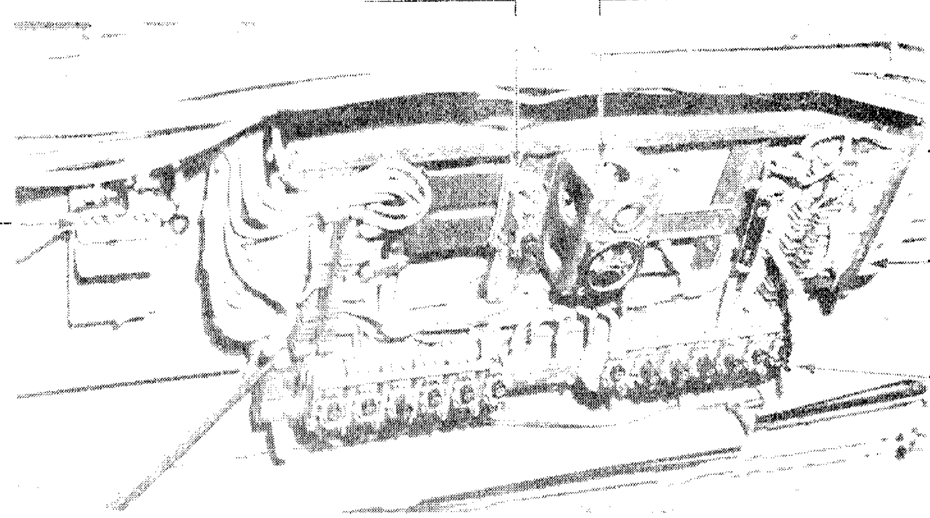
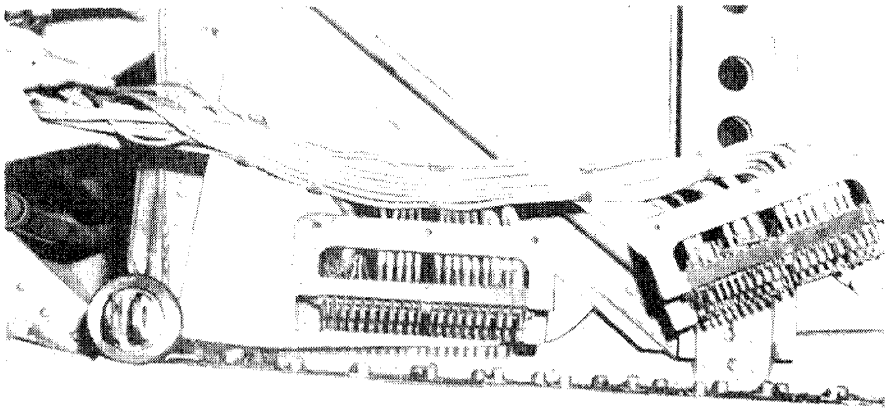
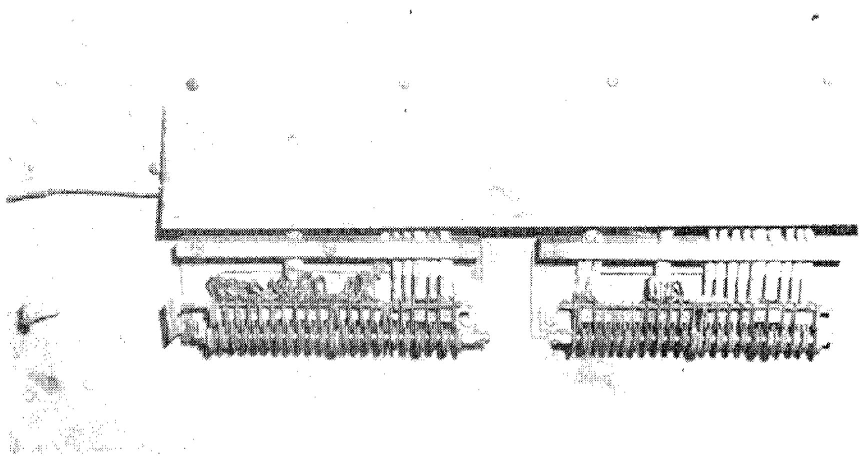


FIG. 6 CIRCUIT BREAKER INSTALLATION



WING UNIT



FUSELAGE UNIT

FIG. 7 CONNECTOR BLOCKS AT WING TO FUSELAGE JUNCTION FIG. 7

ELECTRICAL EQUIPMENT

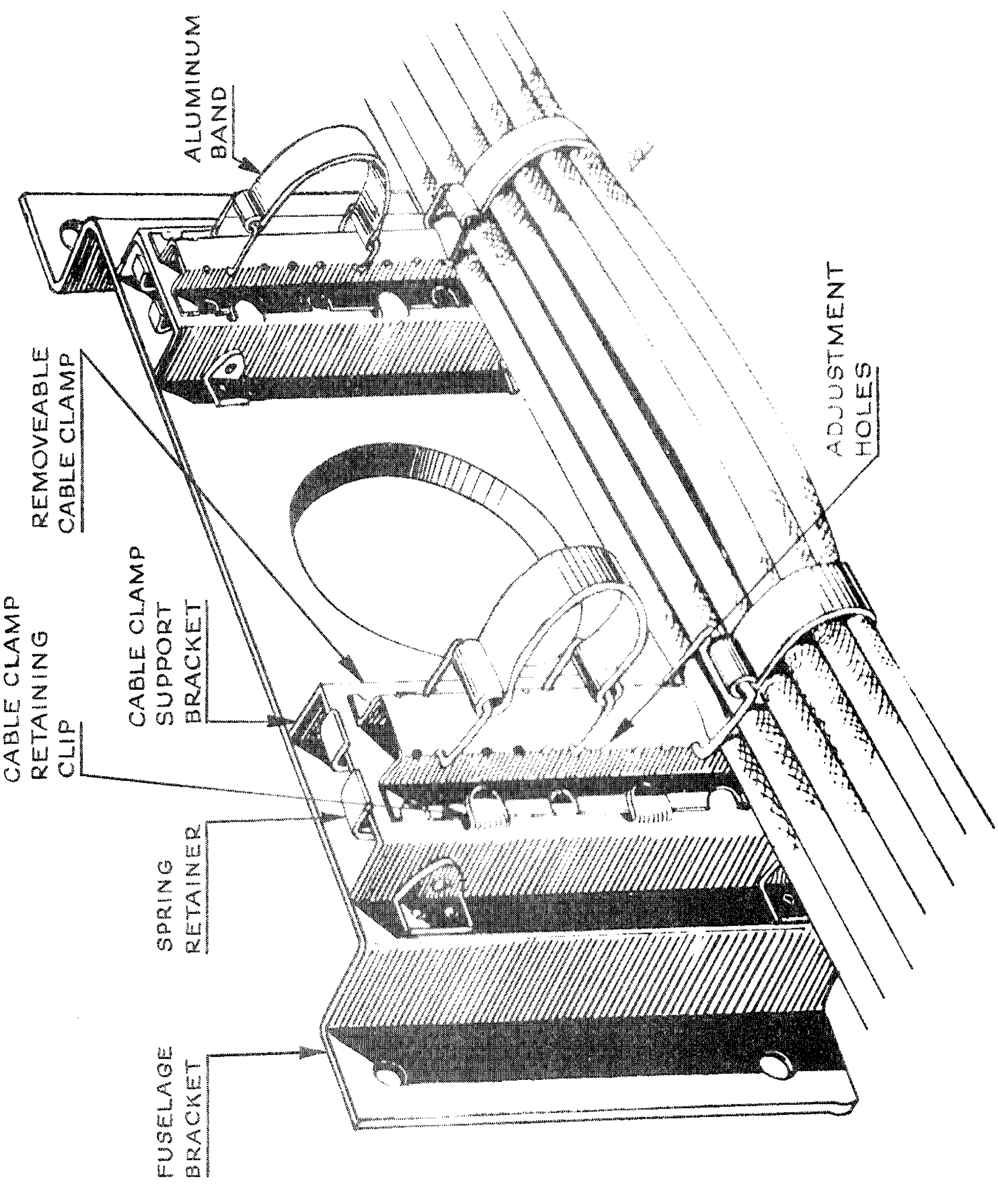


FIG. 8 CONDUIT INSTALLATION FIG. 8

ELECTRICAL EQUIPMENT

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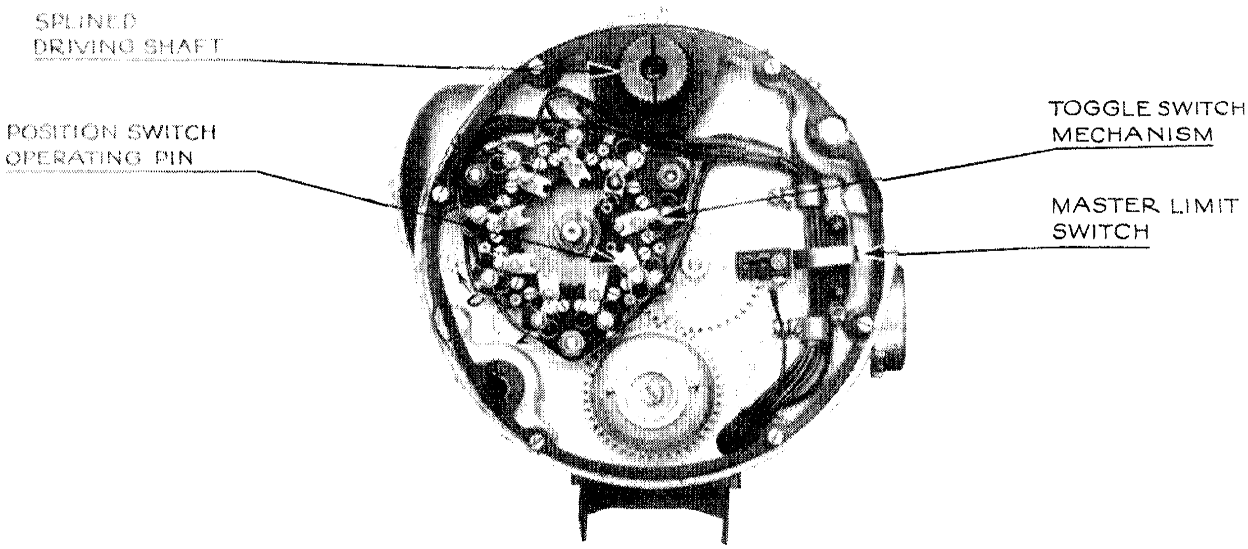

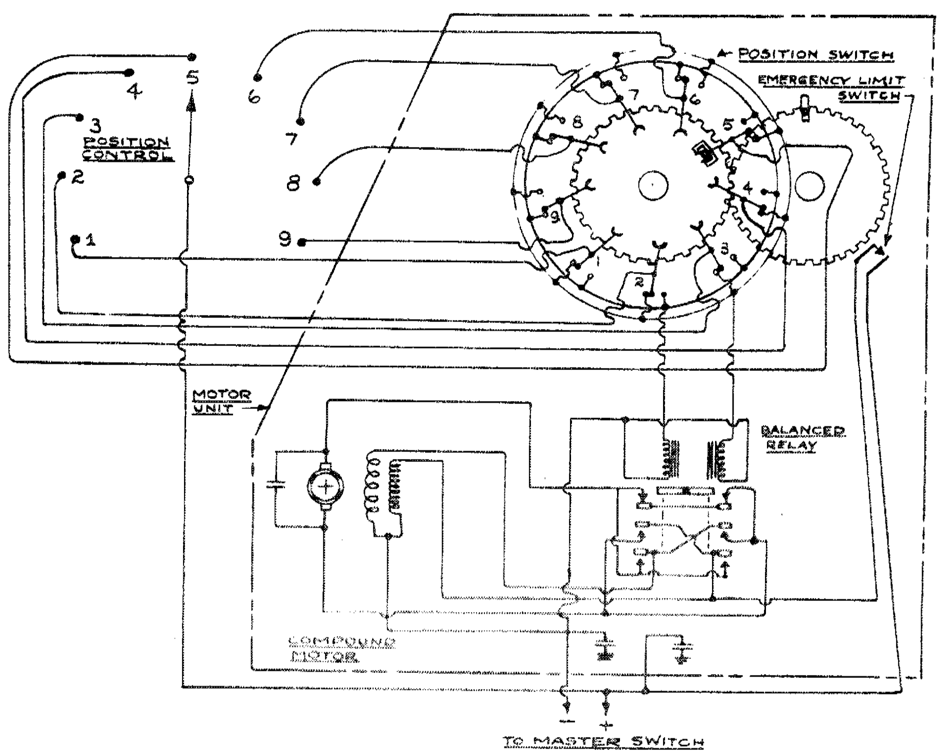

FIG. 9 RADIATOR SHUTTER MOTOR & DIAGRAM FIG. 9

ELECTRICAL EQUIPMENT

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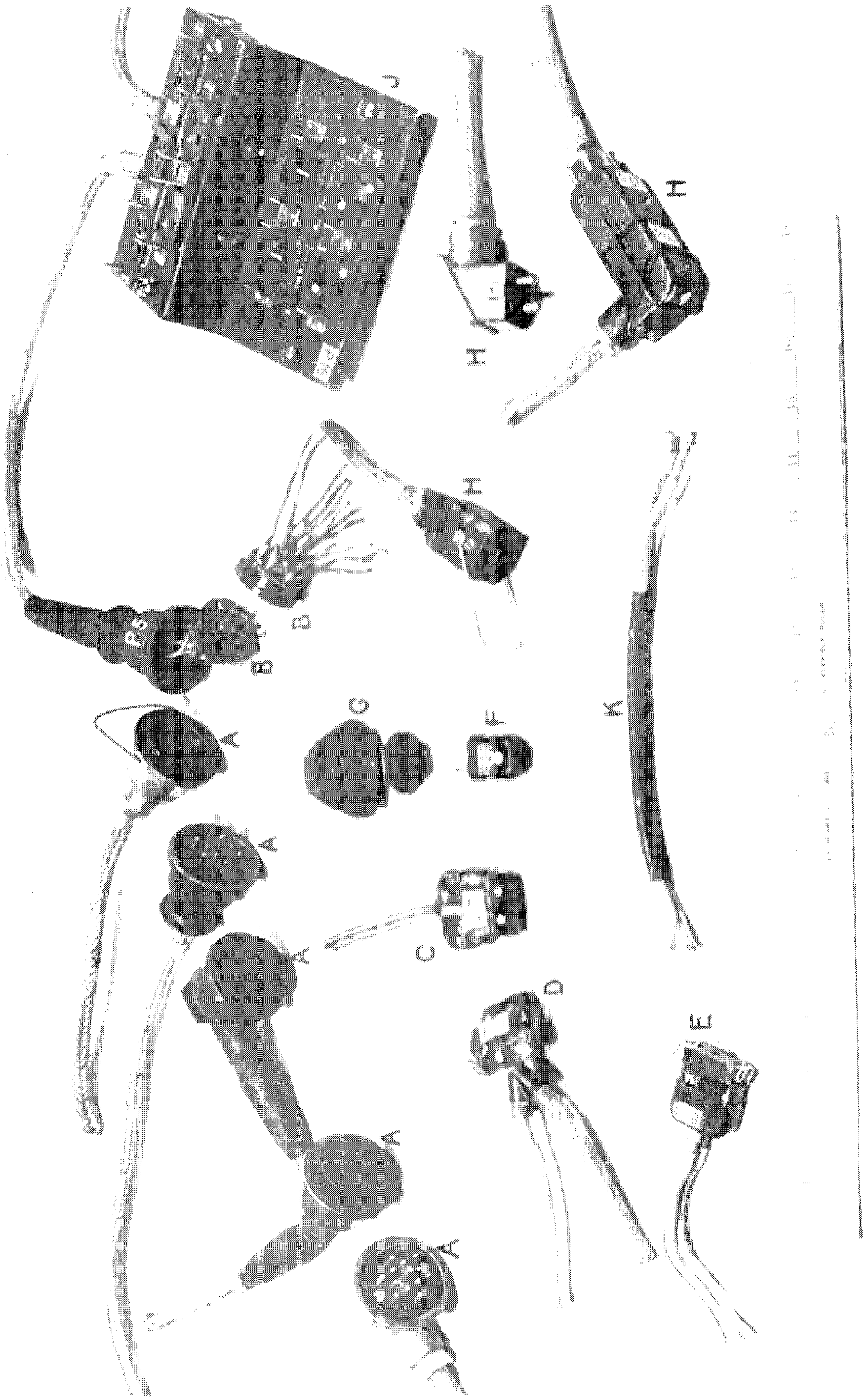

FIG. 10 ELECTRICAL PLUGS FIG. 10

Chapter 4
PNEUMATIC EQUIPMENT

SECTION III

Chapter 4

PNEUMATIC SYSTEM

The Messerschmitt Me110 uses several compressed air systems---in contrast to American airplanes, wherein compressed air systems are scarcely used at all. The fixed machine guns, and the cannon are charged by a high-pressure air system controlled by electrically-operated valves. These systems are described in Chapter 10, "Gunnery Equipment".

Another compressed air system provides emergency operation of the landing gear and wing flaps. This system is charged to an initial pressure of about 2,300 lbs/sq.in., and provides for extension of the landing gear and lowering of the wing flaps in event of complete failure of the hydraulic system. This system, together with its operating units, is described in Chapter 2, "Hydraulic Equipment".

PNEUMATIC EQUIPMENT

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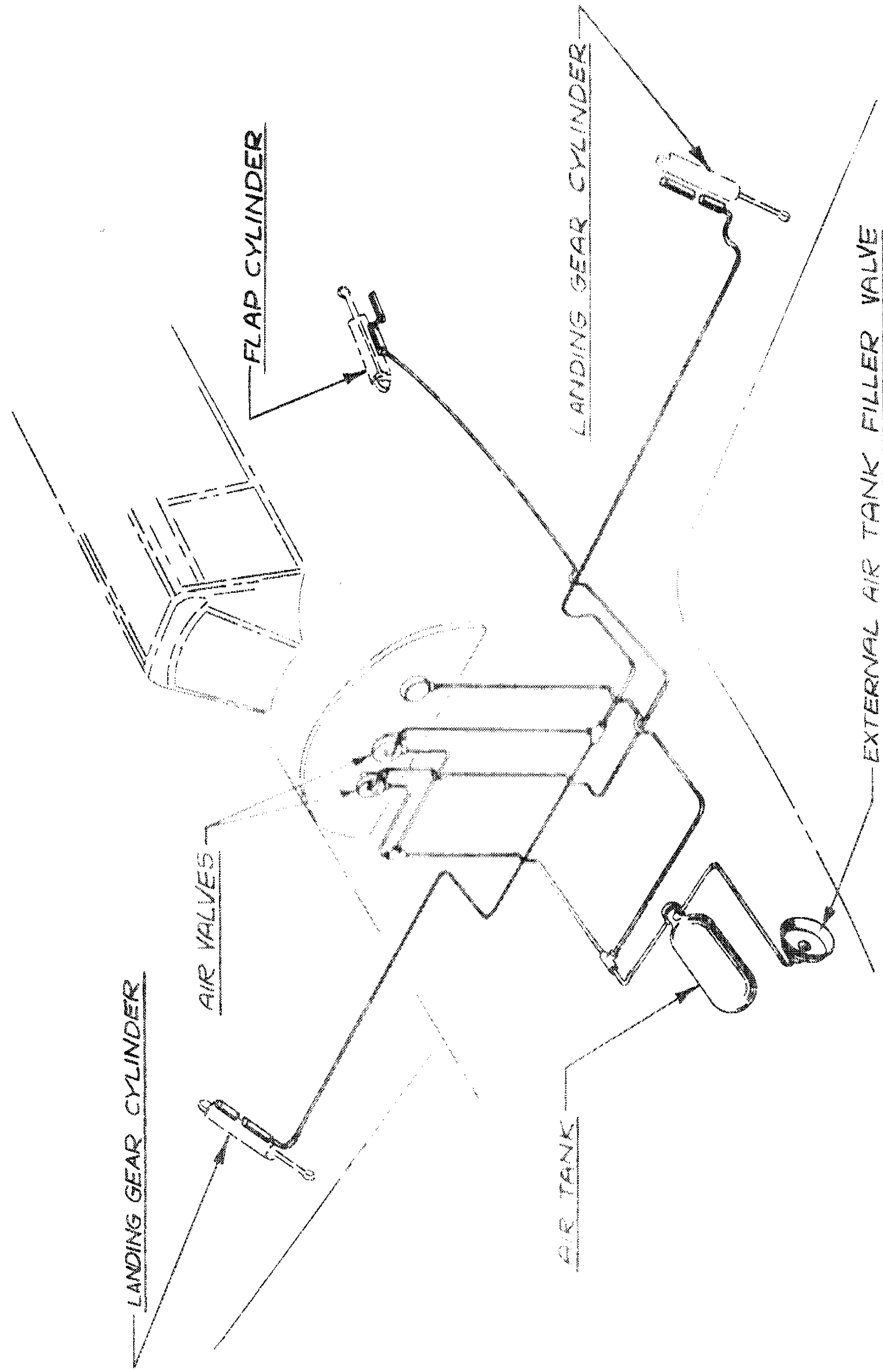
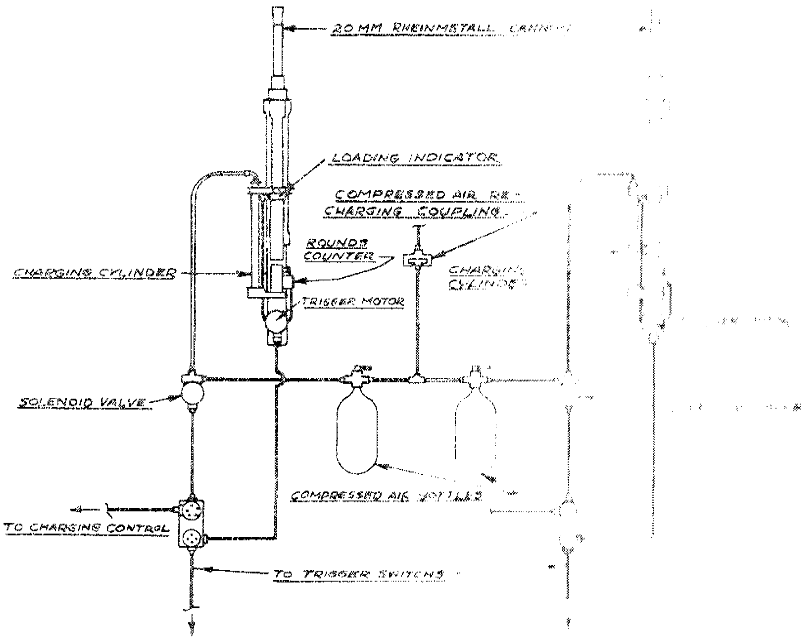


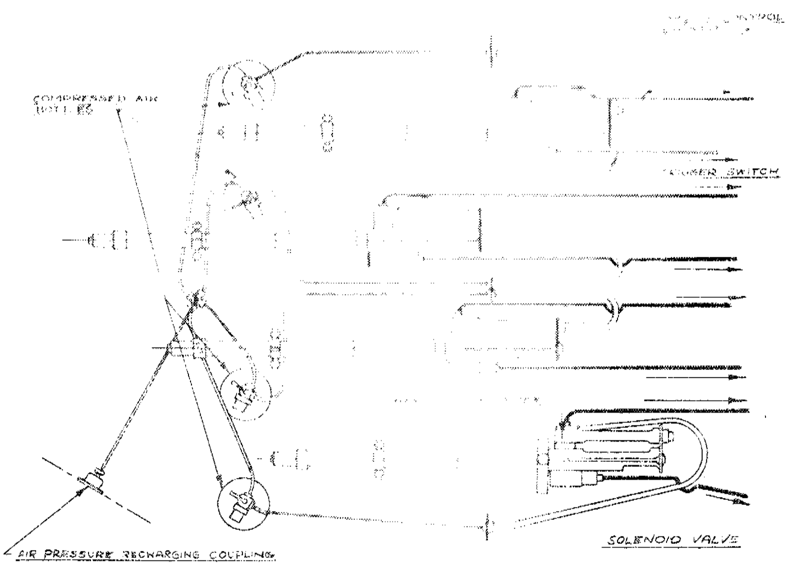
LANDING GEAR & WING FLAP AIR PRESSURE DIAGRAM

FIG. 1 FIG. 1

PNEUMATIC EQUIPMENT



CANNON AIR PRESSURE DIAGRAM



NOSE GUN AIR PRESSURE DIAGRAM

Chapter 5

FUSELAGE EQUIPMENT

Chapter 5

FUSELAGE EQUIPMENT

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FUSELAGE EQUIPMENT

Instruments

The pilot's instrument panel has a flight group consisting of air speed, turn and bank, rate of climb and flight indicators; altimeter; and remote-indicating compass. The engine group includes a tachometer, coolant temperature indicator and manifold pressure gauge for each engine. Coolant Radiator shutter control switches are also provided. The fuel measuring system includes a low fuel level warning lamp for each tank. Space provisions indicate that a propeller pitch indicator was originally provided for each engine.

A small instrument panel is mounted in the navigator's cockpit, but all instruments had been removed prior to their investigation. These instruments were probably used in connection with the navigation of the airplane.

Two small incandescent lamps directly above the instrument panel illuminate the instruments and also serve as cockpit lamps. An attempt was made to shock-mount the main panel in the pilot's cockpit with rubber grommets around the attaching screws. The sub panel carrying the remote compass indicator and radio compass azimuth control was mounted on standard "Lord" type shock-mounts.

The remote indicating compass is of the D.C. Selsyn type, with the compass itself mounted well aft in the fuselage.

Airspeed indications are taken from an electrically heated pitot head installed well out on the wing. The pitot-head tube apparently extended

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Editor's Note: The technical data for this portion of the Messerschmitt Analysis was contributed by Messers H.A. Gibb, and R.E. Krueger of the Engineering and Development Dept. of Vultee Aircraft, Inc.

straight down from the 50% chord point on the wing. A complete description cannot be made, as this item was completely destroyed when the airplane landed in England.

Vacuum for the bank-and-turn and flight indicators is supplied by an engine-driven pump provided with regulating valve. There is no alternate source of vacuum.

All electrical instruments are provided with disconnect plugs, and all instruments requiring hose connections are provided with hose nipple and a length of hose held in place with a simple snap-ring retainer instead of a screw-clamp.

The instruments do not have the finished appearance of American made equipment, but those tested were found to be quite accurate.

Cockpit Enclosure

The cockpit enclosure consists of six assemblies: windshield section; two hinged side panels and one top section for the pilot, one fixed enclosure; and a movable gunner's enclosure. The windshield is attached with four bolts to the fuselage structure, and supports the forward hinges of the side panels and the lock for the top section. The fixed enclosure section supports the aft end of the pilot's enclosure section, and bolts to the fuselage structure at six places. The gunner's enclosure is held by four pins which can be released for jettisoning this section.

The windshield assembly is a welded steel tube frame, with transparent-plastic panels attached by means of aluminum alloy strips at each side of the panels. The attaching screws for these strips pass into the steel tube frame, with access to the screwdriver-slotted nuts inside the tubes provided by holes on the in-board side of the tubes. The windshield front and side panels are 1/4 in. thick transparent-plastic, routed along the edges to provide a flush joint with the attaching strips. The windshield left-hand panel is in two parts, with the forward portion hinged and fitted with bolt-locks to provide a door; presumably for cleaning the outside of the windshield. No reinforcing edging is used on the door panel, with hinges and locks being directly attached to the plastic. The upper panel of this assembly is 1/8 in. thick plastic: formed to make part of the crown. A joggled splice-strip is used to eliminate accurate trimming where the windshield assembly joins the fuselage skin.

The hinged side panels of the pilot's cockpit are welded steel tube structures, with each provided with two transparent panels; a forward sliding panel of 1/4 in. plastic, and an aft fixed panel of 1/8 in. plastic. The rear edge of the sliding, and the forward edge of the fixed panels are beveled, and use a spring cushion on the inside of the sliding panel track to give a flush joint at closed position. The upper edges of these side panels fit inside the top panel when the pilot's enclosure is closed. A single lock in the forward edge of the top panel secures the entire pilot's enclosure.

The top panel of 1/8 in. thick transparent plastic is provided with fabric-strap hinge-stops strong enough to provide a stop for normal use, but certain to fail in case of emergency opening of the enclosure during flight, and thus permit the top panel to carry away.

The fixed enclosure has square steel bows welded to fore and aft members, and is covered with transparent plastic panels attached with screws passing through metal strips.

The gunner's enclosure structure is also constructed of welded steel tube and consists of three main parts; a tiltable hood at the aft end, a jettisonable fixed section forward of the hood, and a sliding top section for the hood. The rear section is hinged to tilt up while the top section lifts slightly from its fixed side panels and slide forward in a guide at the center of the fixed portion of the gunner's enclosure. These three units are linked together and balanced with a bungee cord to permit opening and closing as a single operation. The complete gunner's enclosure is held in place by four pins and can be jettisoned by releasing the pins by movement of a handle located near the flexible gun.

In general, the cockpit enclosure shows evidence of considerable hand fitting, but its design is such that it should assemble without much difficulty. While the structure is very rigid, the exterior is not as smooth as the enclosures of modern American airplanes.

Pilot's Seat

The general design and construction of the pilot's seat is good. The seat proper is formed from light-metal alloy approximately .040 in. thick, and essentially consists of two large drawn parts. One of these includes the back and sides, and the other is the bottom; with the two joined by a riveted lap. A heavy bead formed around a 5/8 in. dia. tube runs around the edge of the seat to provide rigidity.

The pilot's seat is supported by two large aluminum-alloy castings bolted to a channel assembly in the bottom of the cockpit. Various brackets and levers used for supports and operating mechanism are sand castings and appear unnecessarily heavy. The seat is attached to its support structure by four hinge bolts, and can be readily removed when these are withdrawn.

Seat adjustment is accomplished by a long handle located at the left side and slightly above the seat bottom. Twisting the handle grip unlocks the mechanism and allows the handle to be raised or lowered, to move the seat in the same direction. The lock is spring loaded and automatically snaps back into the nearest of five latched positions when the grip is released. A strong bungee aids in raising the seat, but the pilot must partially lift his weight from the seat when moving to an up position. A small fore and aft movement is provided by the arcs of the seat support links, with the seat moving slightly forward when lowered. The range between the high and low positions is approximately 4-3/4 in., with five equally spaced intermediate positions. This varies from the U.S.A.C. standard seat which requires a minimum total adjustment of 7-1/2 in., with sixteen equal adjustments therein.

The safety belt system consists of shoulder and lap straps of two-inch wide webbing, with various buckles providing length adjustments. Both ends of the lap strap have loops with triangular rings, and these rings are attached to brackets riveted to the sides of the seat. The shoulder straps are provided with an adjustment controlled by a lever at the seat's lower right-hand corner. Placing this lever in the released position by moving it up and outward, allows the pilot to pull the shoulder straps against a light bungee and obtain the correct length adjustment [illegible] is obtained the control lever can be returned to the [illegible] to lock the shoulder straps. All belt buckles terminate at the approximate location of the pilots stomach and have triangular shaped rings. The hook arrangement for fastening these rings is evidently a part of the pilot's parachute harness.

The seat is quite accessible, with the cockpit and enclosure openings being amply large for ready entrance and exit. Hand-grips provided on each upper corner of the windshield frame assist entrance and exit, and a small heel-rest channel is provided on the floor. The seat is comfortable, and although the cockpit is narrow it is not cramped, with the cockpit opening at the enclosure deck being twenty two inches wide. This is two inches narrower than U.S.A.C. minimum requirements. Rudder pedals and stick are positioned with reference to the seat to provide ease of operation. Undoubtedly a pilot could fly the Me110 for a considerable period without undue strain or fatique.

Gunner's Seat

The construction of the gunner's seat is quite simple, and comprises three major parts; sides, bottom, and mounting post. The top is a stamping .064 in. light metal sheet. The upper edges are rolled around a 5/8 in. dia. aluminum-alloy tube to form a large bead. The bottom and the mounting post are light-metal sand castings, and appear unnecessarily heavy. The upper stamping, rivets to the bottom casting. Two stowage brackets are mounted under the seat.

The seat mounting post is attached to the airplane structure by four bolts passing into nut plates under the floor, in a position slightly to the left of the airplane's center line. Thus the seat is mounted on a vertical axis, and is free to rotate 360° against a light friction brake, making it possible for the gunner to quickly change his position from facing forward to a firing position facing aft. Although the safety belt is missing, it can be assumed from the belt mounting brackets that this safety belt is similar to the pilot's belt previously described.

Although the seat is not too comfortable, it provides ample free movement for the gunner. The seat sides are low, allowing ample elbow room and free arm movement. The seat back is a very odd shape to permit the gunner to lean far back when firing upward. Necessary hand grips and steps are provided, with the cockpit and enclosure openings being amply large for free entrance and exit.

Navigator's Seat

The navigator's seat is installed upon the wing main-beam truss within the fuselage, and is a thin, semicircular magnesium casting, supported at the aft end upon the upper truss member and at the forward end by brace tubes extending downward to the lower truss member.

There is no evidence of a seat back, but it may be that a similar casting was installed as a seat back, in such a manner that it could fold down on the seat to facilitate entrance and exit; or that a wide web-belt seat-back arranged for ready removal and stowage was used. This seat appears rather small and uncomfortable for flights of any duration. There is no evidence of safety belt being attached, although belt provisions were undoubtably made in some manner.

Cases and Containers

Various cases and containers are installed in the Messerschmitt cockpits. A small case at the left of the pilot's cockpit is probably a data case for books and maps, as this container has neither lid nor retainer for its contents, which were evidently bulky enough to remain in place during flight maneuvers.

Another small container is mounted at the right side of the pilot's cockpit, in a location about opposite the pilot's elbow. A spring loaded lid is provided for this container, which may have been for emergency rations.

A third container in the pilot's cockpit is mounted high on the left side, and was probably used to carry flight reports, as clips are provided to secure the contents. All three containers in the pilot's cockpit are constructed of aluminum alloy, with the larger of these containers having welded edges, while the other two are riveted.

A large carrier-pigeon box is located just aft of the gunner's compartment at the right hand side, and mounted to permit quick removal. Leather strap hand grips are provided on each end for ease of handling. The opening is covered with two spring loaded doors, and the interior is felt lined. A large record book is mounted on one side, and is provided with a leather strap retainer at its top center.

Steps, Ladders, and Assist Handles

The principal access to the Me110 is from the left-side, by means of a retractable ladder located on the lower portion of the fuselage aft of the wing trailing edge. This ladder is completely flush in the retracted position, and is extended by pushing a small, flush button; whereupon the ladder drops into extended position to expose three rungs.

In conjunction with the ladder there are flush-type hand-grips mounted in the fuselage, which have spring-loaded flush doors. The inside of the hand-grip openings are sealed with suitable fabric bags, to keep foreign matter from entering the fuselage.

In the upper aft corners of the windshield are two handles to assist the pilot on entering or leaving the cockpit. Also, on the pilot's floor is a transverse foot-rail, to give support when entering or leaving the cockpit.

The navigator has three handles located on the cockpit upper stiffeners, two on the left hand side, and one on the right hand side. These are located well forward, for use when loading the cannons or operating the radio equipment.

Hoisting Lugs

Provisions are made for four fuselage hoisting points. These are sheave-fittings,forged as part of the main spar lower attachment fittings and the forward sub-spar attachments. These four fittings are placed fore and aft of the center of gravity to balance the airplane during hoisting.

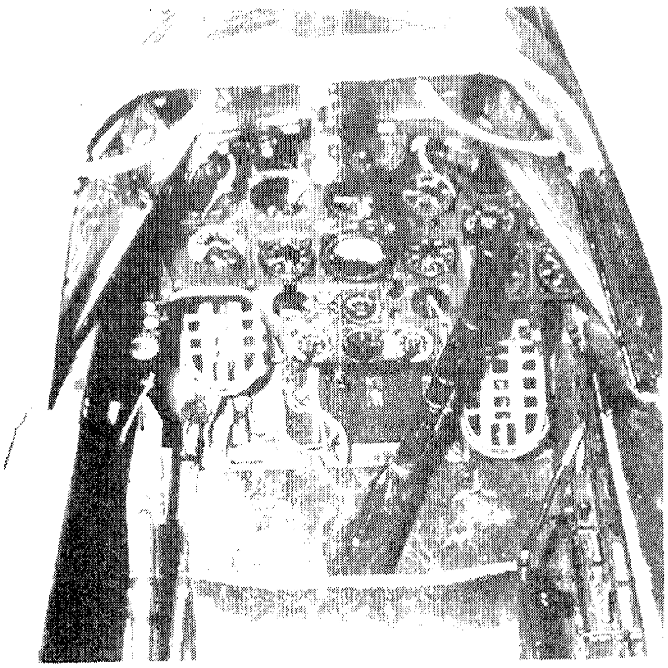
Another hoisting device is provided in the forward portion of the nose-gun compartment, ahead of the ammunition boxes. This is a cross-tube attached inside the nose-section structure, and is normally closed by a flush cover plate at each end. With the lower plates removed, a bar of approximately 1-1/8 in. dia. can be passed through the tube for lifting the nose-gun compartment during removal and installation operations.

Life Raft

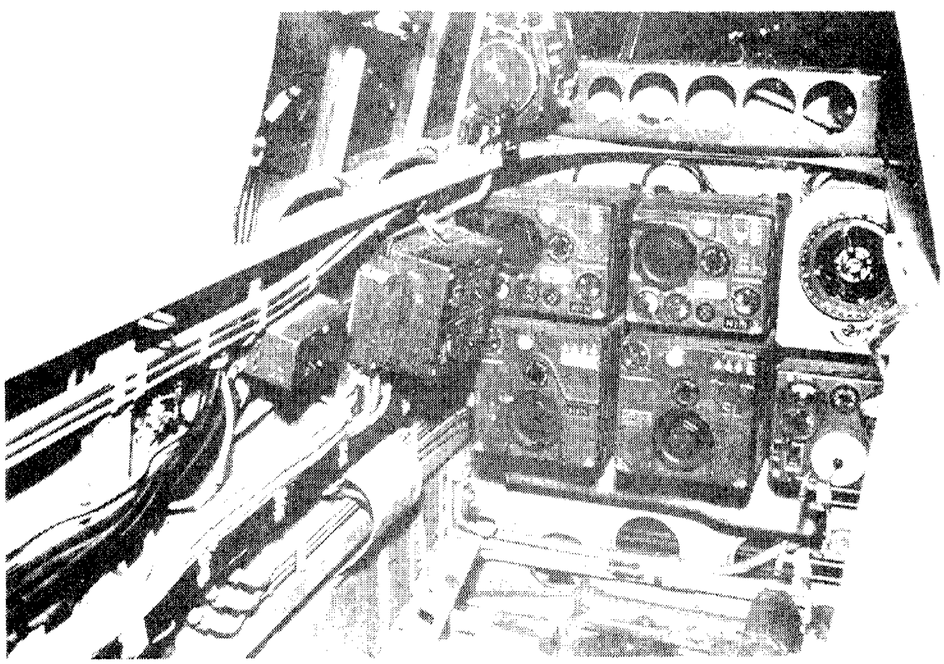
The tail cone provides stowage for a life raft. In event of an emergency water-landing, the tail cone can be jettisoned by a latch controlable from the gunner's cockpit. Upon being released the tail cone opens about a hinge at the aft end and releases the life raft. A light cable held in clips along the outside of the fuselage provides for the raft being towed forward to the crew. It is then inflated and fitted with oars or paddles for use as a dingy. Unfortunately, the collapsible life raft was missing from the airplane received by Vultee, so details regarding its construction are unavailable.

Relief Tubes

Although the Me-110 is a long range fighter, there was no evidence of relief tube provisions.

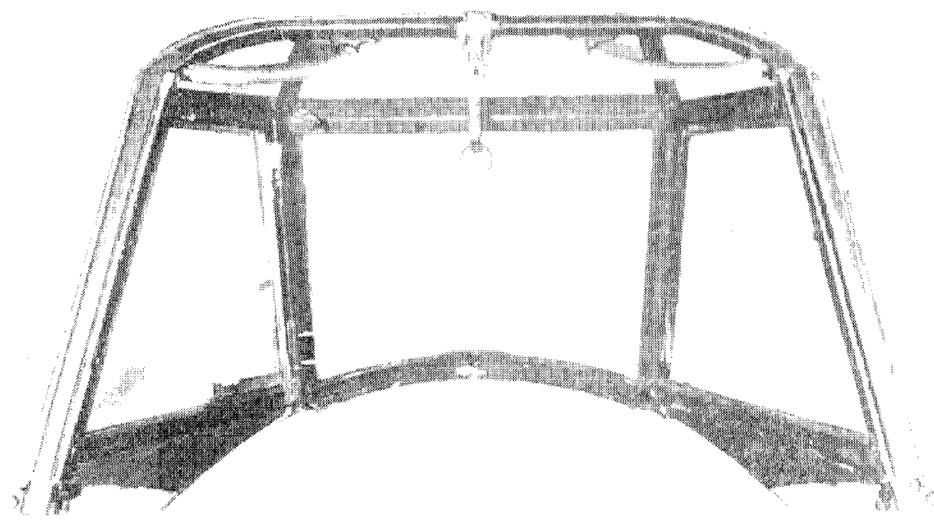


PILOT'S INSTRUMENT PANEL



NAVIGATION & COMMUNICATION EQUIPMENT IN REAR COCKPIT

FIG. 1 PILOT'S & NAVIGATOR'S INSTRUMENT PANELS FIG. 1



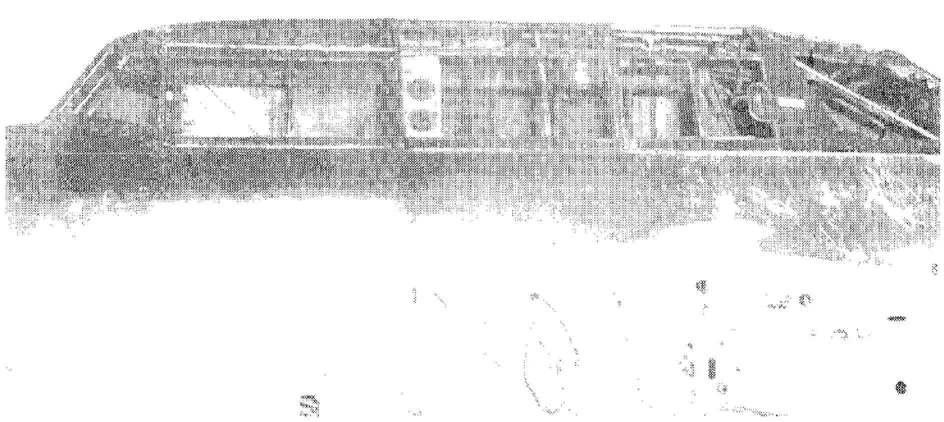
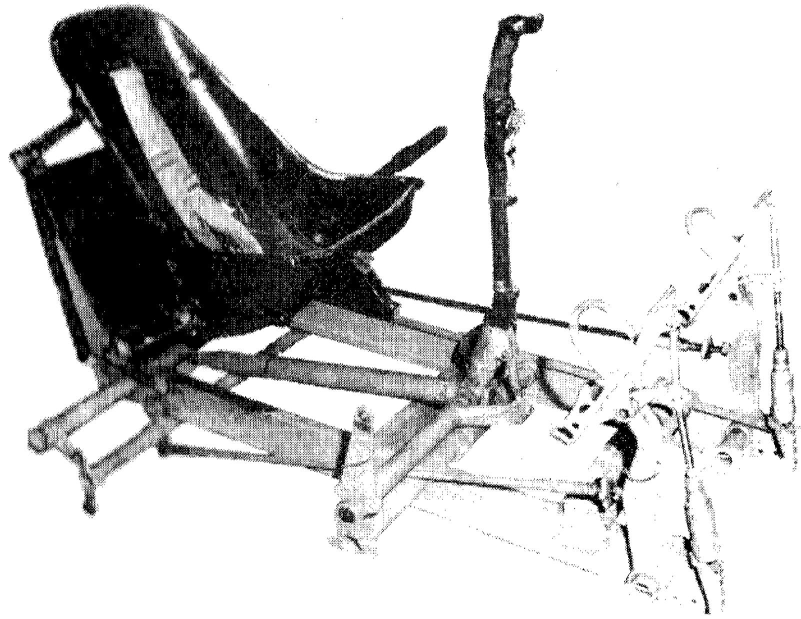


Fig. 2 COMPLETE COCKPIT ENCLOSURE & WINDSHIELD ASSEMBLY Fig. 2

FUSELAGE EQUIPMENT



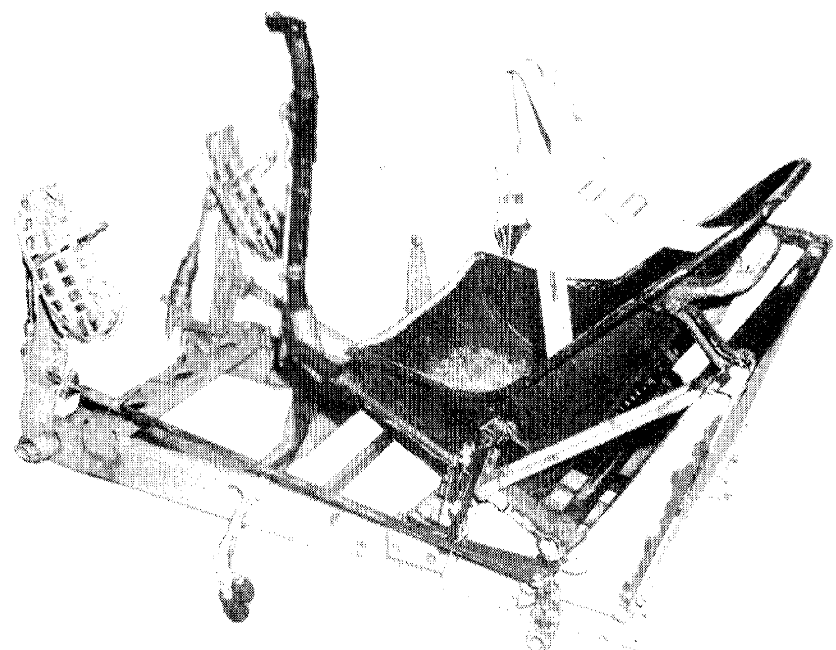


FIG. 3 PILOT'S SEAT

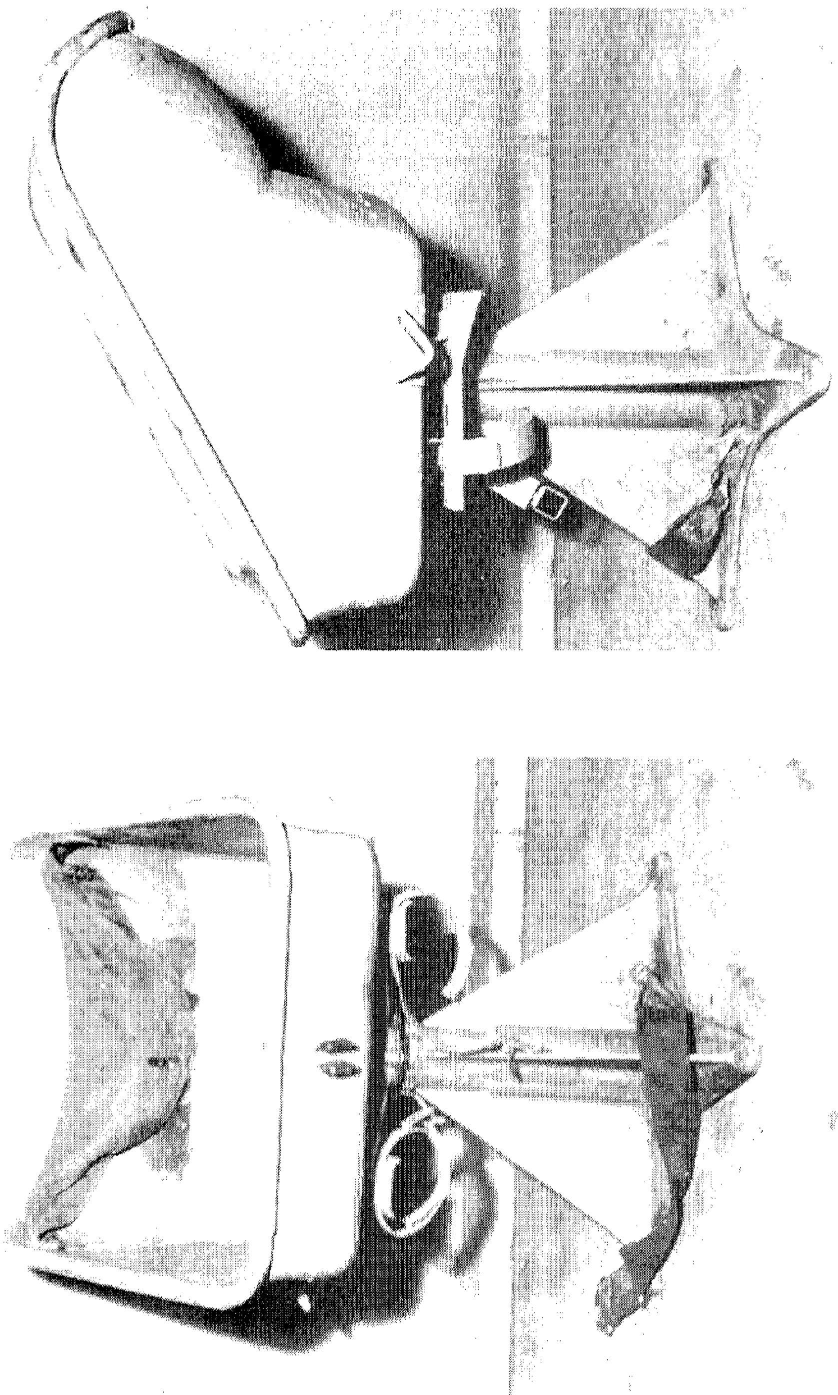


FIG. 4 GUNNER'S SEAT FIG. 4

FUSELAGE EQUIPMENT

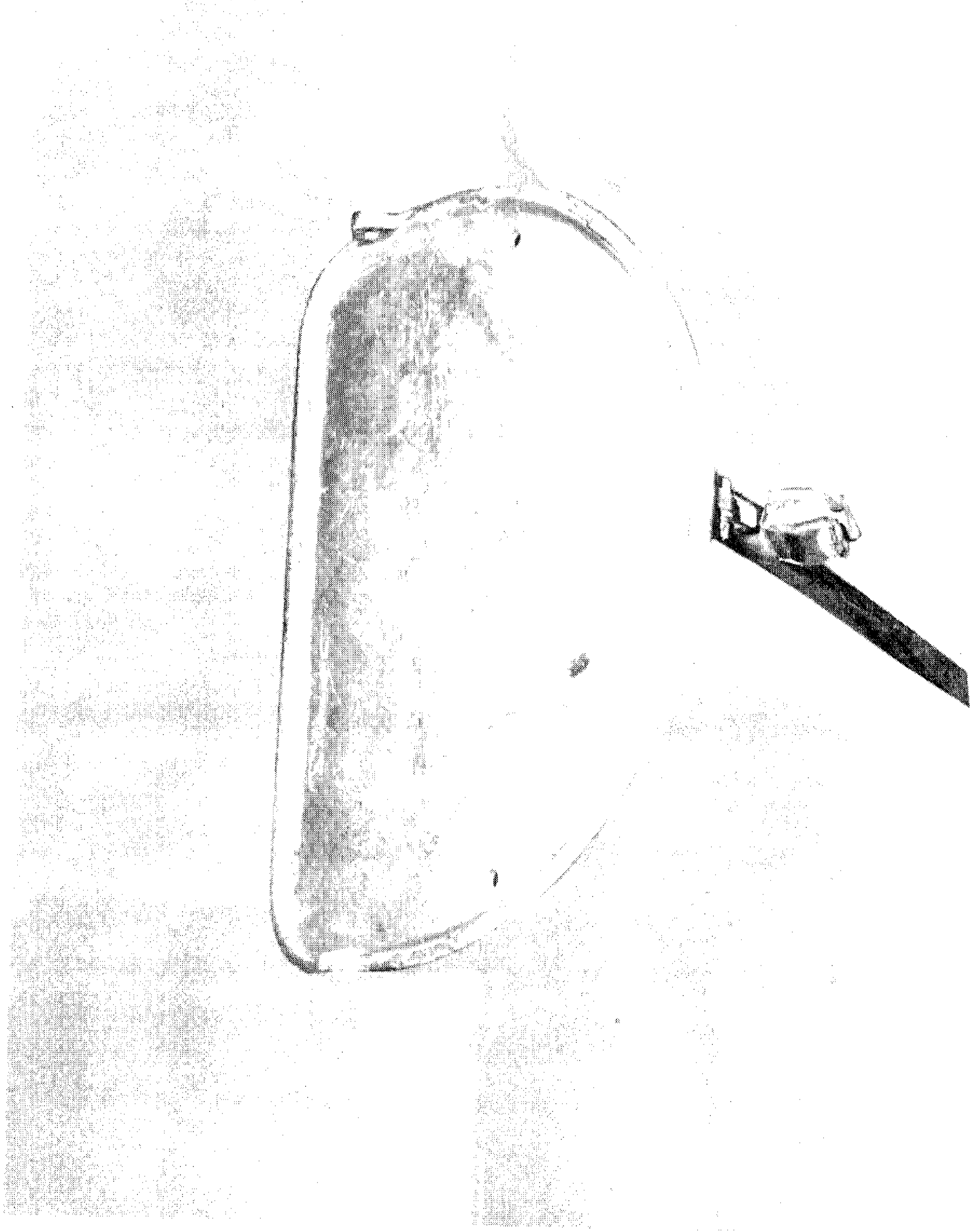
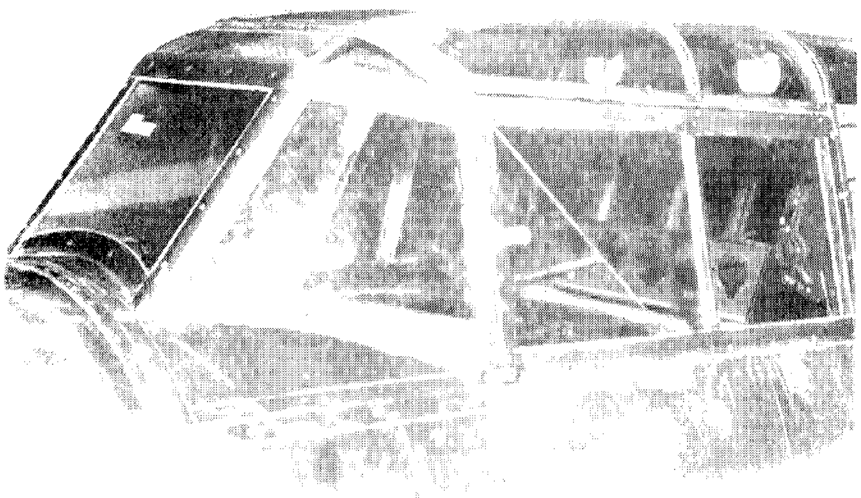
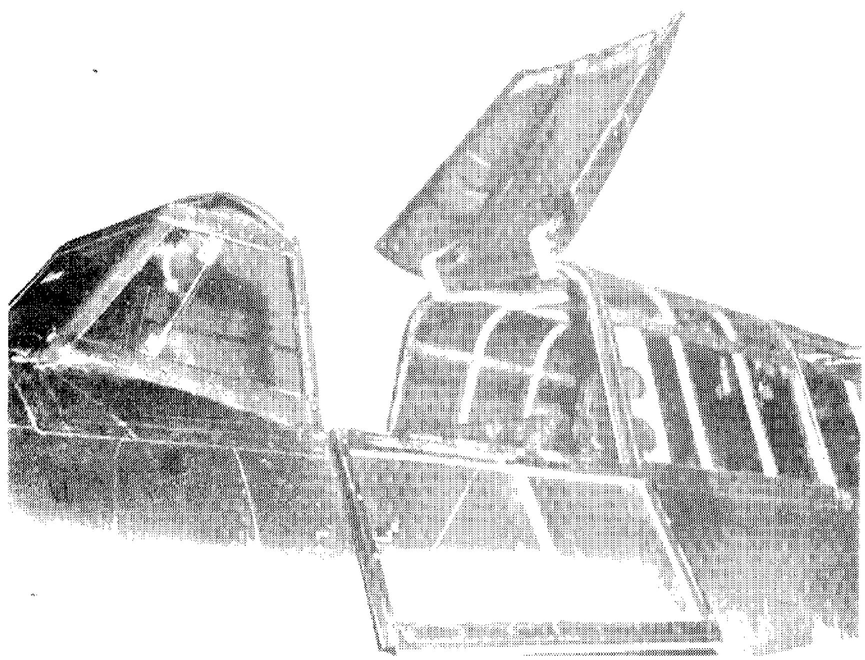


FIG. 5 NAVIGATOR'S SEAT FIG. 5

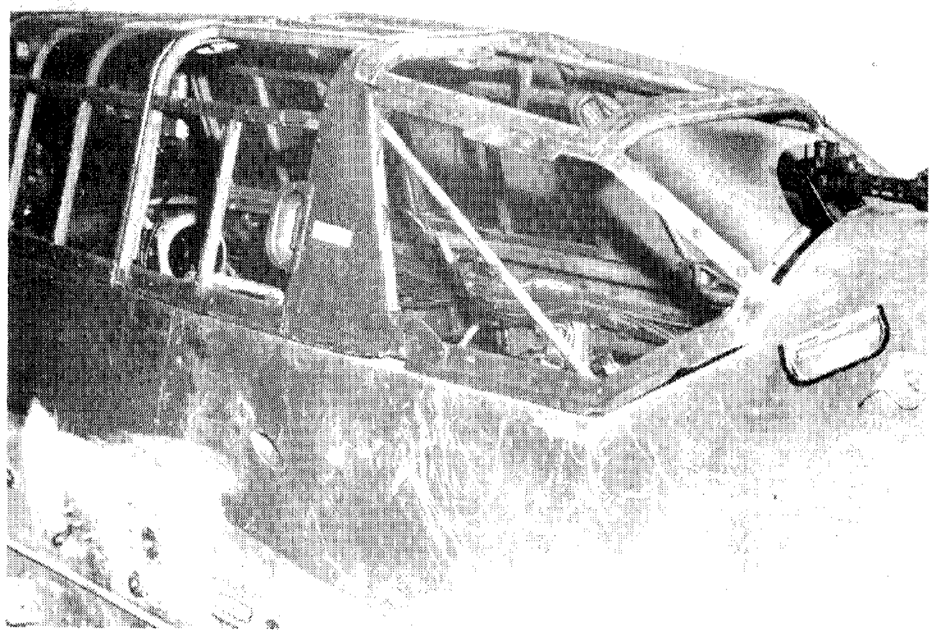




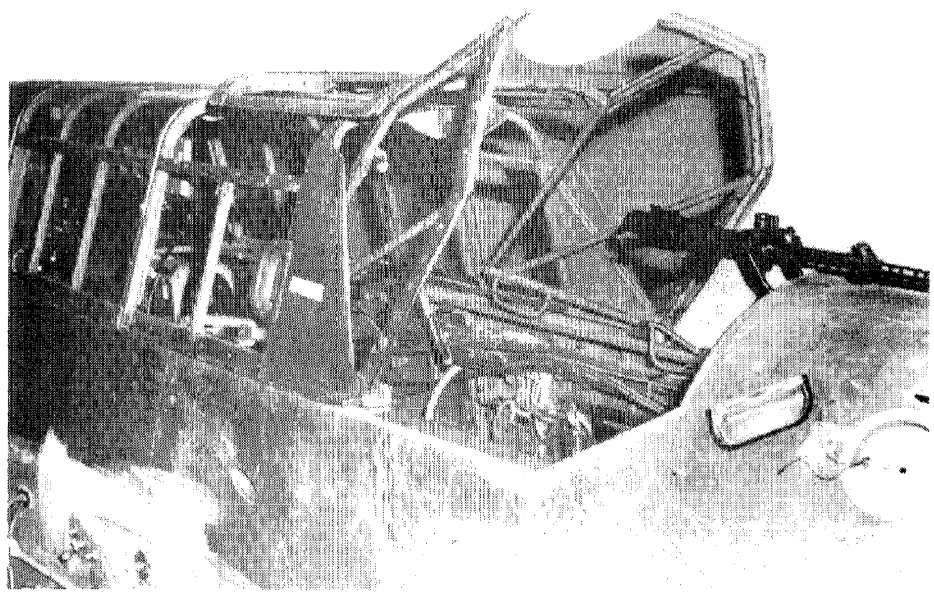
Open

Fig. 6 — PILOT'S COCKPIT ENCLOSURE — Fig. 6

FUSELAGE EQUIPMENT



CLOSED



OPEN

FIG. 7 GUNNER'S COCKPIT ENCLOSURE FIG. 7

Chapter 6

HEATING & VENTILATING SYSTEM

SECTION III

Chapter 6

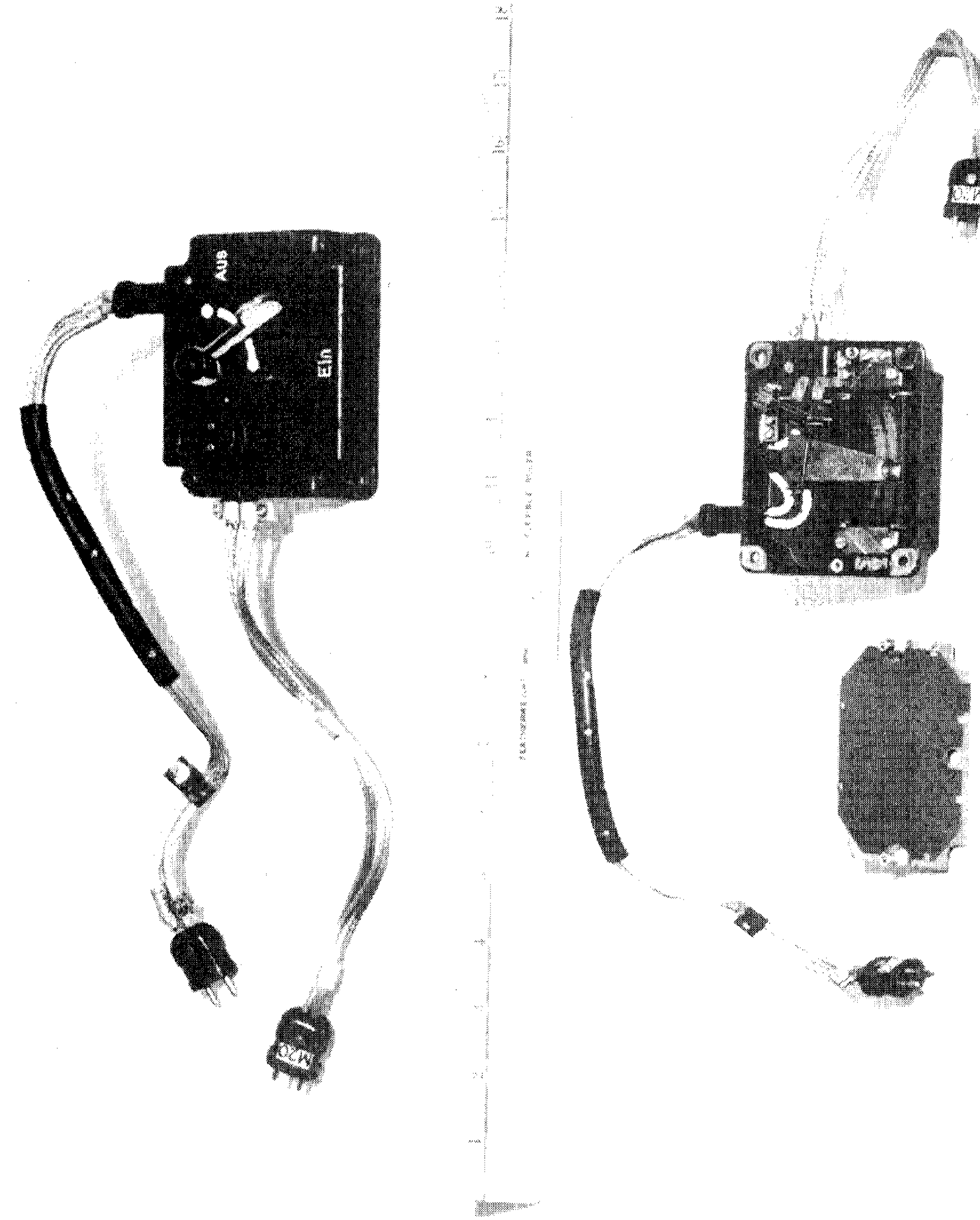
HEATING AND VENTILATING SYSTEM

The Me110 is not provided with a heating and ventilating system as we are accustomed to think of this feature. There is no provision for admitting warm air to the cockpits, and the only provision for cold air admission is by means of the emergency vision panel, and sliding panels in the pilot's cockpit side enclosures.

Provisions are made, however, for use of electrically-heated flying suits by each of the crew members. A small control box with a rheostat, having an off position, is provided at each crew station. Each control box is provided with a two-terminal receptacle to receive the suit-heater cordage-plug.

HEATING & VENTILATING EQUIPMENT

SECTION III CHAPTER 6



PILOT'S & NAVIGATOR'S

FIG. I SUIT HEATING SWITCH & PLUG BOX FIG. I

Chapter 7

FIRE EXTINGUISHING EQUIPMENT

SECTION III

Chapter 7

FIRE EXTINGUISHING EQUIPMENT

The Me110 is not provided with engine fire extinguishers, and there were no hand-type extinguishers in the airplane when received by Vultee Aircraft. There are, however, a pair of brackets in the gunner's cockpit that could have been used to stow an extinguisher.

Under the gunner's seat are two clips attached to the seat bottom, and straddling the seat support post. These clips are very similar to the hand fire extinguisher brackets used in this country and may have been used to stow a small hand type extinguisher. This location does not meet American requirements, which specify that the fire extinguisher must be accessible from both inside and outside the airplane.

Chapter 8

OXYGEN EQUIPMENT

SECTION III

Chapter 8

OXYGEN EQUIPMENT

The oxygen system of the Me110 is well designed, and the installation is very simple -- with the cylinders being placed far aft to afford protection to the crew from possible explosions resulting from the cylinders being struck by gunfire.

Two complete systems are used: one for the pilot, and another for the gunner and navigator. Ease of servicing is provided by exterior charging connections.

Eight oxygen cylinders are vertically mounted in the extreme rear, left-side portion, by small cups fitting the base of the cylinders and a channel with appropriate holes to fit over the neck of each cylinder. This channel is connected by four long bolts to the base-cup support member. Additional support is provided by a formed hat-section developed to bear against the wall of each cylinder, and attached to the side of the fuselage by four bolts located at equal intervals between the cylinders.

The oxygen cylinders are grouped in two sets of four, with each cylinder in a group being interconnected by a loop of [illegible] in. O.D. copper tube. Each group of cylinders is connected to a [illegible] in. O.D. copper tube which leads forward to the cockpits. One of these delivery lines leads directly to the pilot's cockpit, and the other line leads to the gunner's and navigator's cockpit. An exterior charging connection is provided slightly aft of the gunner's cockpit, arranged for access from outside the airplane by removing a flush cover, and connected to both delivery lines. A pressure regulator is provided for the pilot, and

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Editor's Note: The technical data for this portion of the Messerschmitt analysis was contributed by Mr. R. E. Krueger, Group Leader in Charge of Fuselage and Furnishing Design for the Engineering and Development Dept. of Vultee Aircraft, Inc.

a second pressure regulator supplies oxygen to both navigator and gunner.

Operation

When the occasion arises to use oxygen a delivery valve is opened to allow oxygen to flow to the related oxygen regulator, which reduces the pressure and exhausts into a rubber and fabric "lung". From the "lung" the oxygen is metered by an adjustable valve to the delivery tube. The delivery tube is a short detachable, corrugated tube with an outside diameter about 7/8 in.. The pressure regulator as a whole seems to be designed to keep the pressure and temperature of the oxygen within comfortable limits. The equipment connecting to the delivery tubes was not found in the airplane, but it would seem that a small flexible hose 3/8 to 1/2 in. O.D. was used in conjunction with a pipe stem bit. This supposition is substantiated by the fact that each member of the crew has within easy access a small clip in which to stow such an oxygen bit.

OXYGEN EQUIPMENT

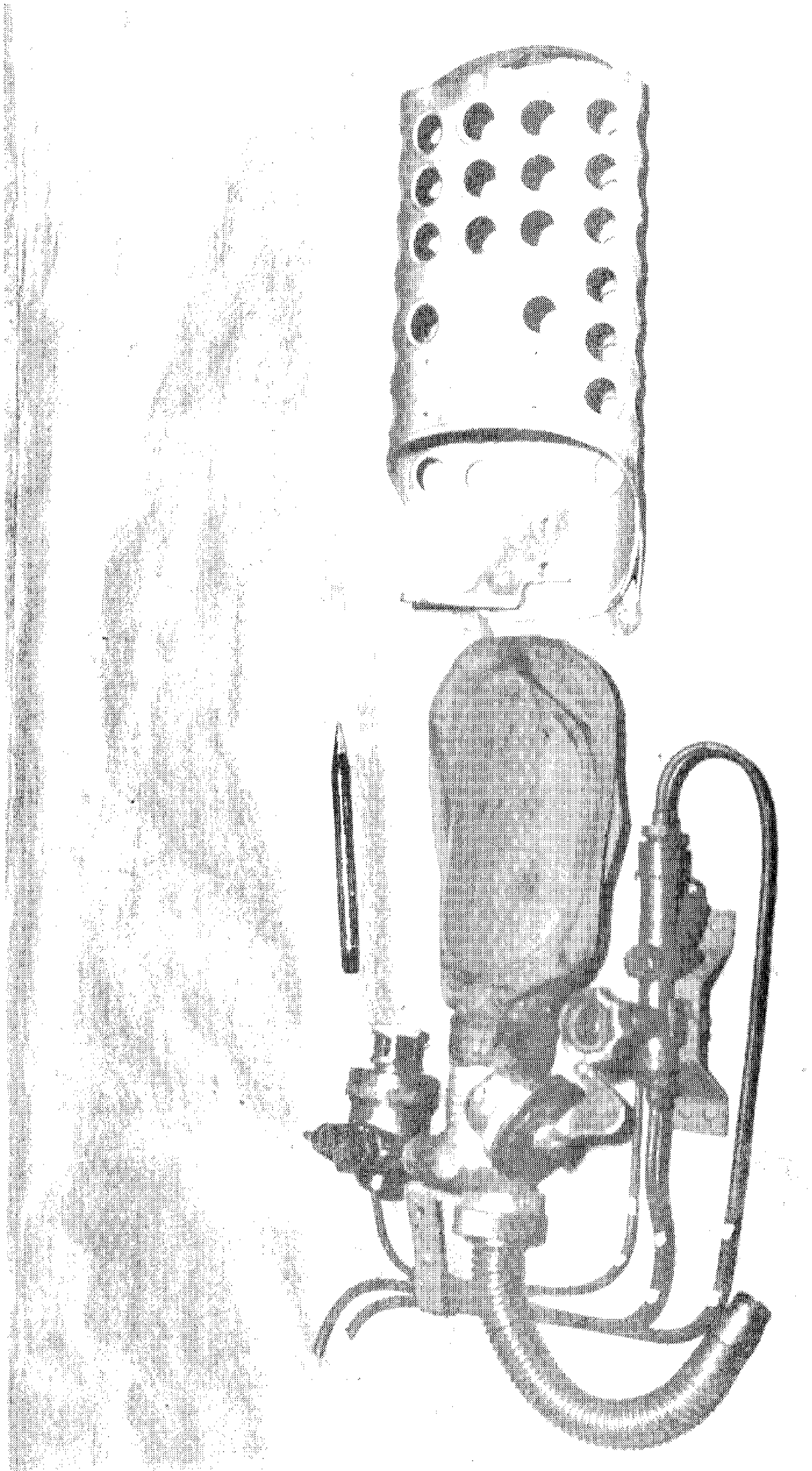

FIG. 1 OXYGEN REGULATOR FIG. 1

Chapter 9
RADIO EQUIPMENT

Chapter 9

RADIO EQUIPMENT

LIST OF CONTENTS