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TECHNICAL REPORT No. 231-45

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MESSERSCHMITT AIRCRAFT DESIGN DEVELOPMENT

AUGUST 1945

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TECHNICAL REPORT No. 231-45

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MESSERSCHMITT AIRCRAFT DESIGN DEVELOPMENT

SUMMARY

This report contains a brief summary of the developmental work being carried out by the Messerschmitt A.G. on high speed jet and tailless fighters at the close of the war.

August 1945

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TABLE OF CONTENTS

	<u>Page</u>
I. <u>High Performance Jet Fighters.</u>	
1. Specifications	3
2. 1101 Development	3
3. 1106 Development	5
4. 1110 Development	5
5. General	5
(a) Power Plant Problems	5
(b) Landing Gear	6
(c) Armament	7
(d) Longitudinal Trim Devices	7
6. Summary of Me 1110 Design Study	7
II. <u>Tailless Studies.</u>	
1. Introduction	10
2. P1111 Development	10
3. P1112 Design Study	11
4. Future Plans	11
Table I	
A. Dimensions	12
B. Weights	13
C. Performance	14

(N.B. This report appeared as Interrogation Report #30 in Joint Army-Navy project of interrogation of Messerschmitt A-6 personnel).

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MESSERSCHMITT AIRCRAFT DESIGN DEVELOPMENT

I. HIGH PERFORMANCE JET FIGHTERS:

1. Specifications.

Messerschmitt started on the preliminary design study of a high performance jet fighter, having the arrow form (high sweep-back wing) about July 1944. The basic requirement agreed upon with the Air Ministry were:

- 1 1/2 hours endurance at approximately 10,000 m. (32,800 ft.)
rated r.p.m.
- 170 km/hr (106 mph) stalling speed at landing weight. (1/3 fuel
and full ammunition.)
- Two (2) 30 mm. machine guns minimum armament.

The He S-011 engine of 2860 lbs. static thrust was selected. The fuel required for the required endurance was 1400 liters (370 U.S. gallons).

2. 1101 Development.

Messerschmitt submitted a proposal to these requirements in September 1944. The model designation was 1101. Authorization to proceed with the design was obtained almost immediately. (Junkers and Heinkel were also given experimental contracts for airplanes to meet the same requirement.) The Messerschmitt design had three (3) 30 mm. guns with a space for 2 additional. Its weight empty was 2600 kg. (5750 lbs.) and gross weight 4000 kg. (8850 lbs.) The wing area chosen was 15.85 sq.m. (170 sq.ft.) giving a wing loading of 52 lbs/sq.ft. on the 8850 gross weight.

($C_{L \max}$ required to give 106 mph $V_S = 1.72$). The wing used was the high sweep-back arrow wing type, having full span slots, plain flaps and conventional, inset-hinge ailerons. The root thickness was 8%, (measured parallel to plane of symmetry) and the tip thickness 12%. The tip was made relatively thick because:

(a) This thickness could be tolerated without compressibility difficulty in view of the three dimensional flow at the tip;

(b) Greatest attainable torsional rigidity was desired to maintain aileron control at high speeds;

(c) The thicker wing per se and the larger chord slat that could be

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1101 Development (Cont'd.)

fitted to it would both help to prevent tip stall.

An incidental advantage was that both the slat and the flap could be made of constant cross section throughout their span. The resulting slat chord was 13% of the wing chord at the root and 24% at the tip. The 1101 airplane was arranged with the engine and intake in the fuselage nose, with three (3) guns, ammunition and chutes wrapped around the duct. The nose wheel of the tricycle landing gear retracted aft, the plane of the wheel rotating 90° for stowage upon retraction by means of a skewed axis joint at the upper olso fitting.

The cockpit was located above the duct and forward end of the engine, making a rather deep fuselage. The fuel was located in the fuselage above the engine, aft of the pilot. The jet discharge was located in a half-tunnel step near the root trailing edge. The airplane was a mid-wing, with the wing structure passing under the fuel and above the engine. The empennage was conventional except that it had rather low aspect ratio, high taper, and large sweep-back of the landing edges of the fin and stabilizers. The main landing gear was pivoted at the fuselage, just under the wing, and retracted aft. As the design work progressed into October 1944, it became apparent that this design would not "jell". The principal difficulties were:

(a) The gun installation around the nose intake duct was very crowded and had poor ammunition boxes and chutes;

(b) The low thrust axis caused large changes of trim with changes in thrust;

(c) The motion of the olso and wheel upon retracting into the fuselage presented a serious closing-door problem;

(d) The grouping of wing, powerplant and landing gear loads was poor, requiring an excessive number of fuselage strong-points, and;

(e) The calculated performance, 985 km/hr., (610mph) was less than desired. For these reasons it was decided to abandon the 1101 as a possible production prototype, but since considerable work had been done, it was to be finished up as a flight test airplane to prove out the arrow wing.

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3. 1106 Development.

Further design studies were immediately undertaken. The next arrangement to take shape had the model designation 1106. (Intervening numbers were given to other than fighter aircraft). This airplane study had the same wing as that described for the 1101. The engine intake was again located in the fuselage nose, and the armament wrapped around the duct. The root leading edge was located well forward, with the wing structure passing below the fuel tank which occupied the upper half of the fuselage, and the engine which was located beneath. The engine outlet again took the form of a stepped half-tunnel. The pilot was located well aft, behind the fuel tank. His landing vision was badly obscured by the wing leading edge. The advantages of this arrangement over that of the 1101 was questionable, so the project was dropped in favor of the layout described below.

4. 1110 Development.

In this next arrangement tried, great effort was made to achieve the smallest possible fuselage cross section. The fuselage nose was carried unusually far forward of the wing leading edge, and housed the three (3) 30 mm. guns. The nose wheel oleo pivot was located far enough aft of the nose to permit forward folding, with the plane of the wheel remaining in the plane of symmetry, between the guns, in the stowed position. The pilot's cockpit was located next aft of the armament, and occupied the entire fuselage cross section. The root leading edges was just aft of the cockpit, and 1200 liters (316 U.S. gallons) of fuel was located in a self-sealing tank in the portion of the fuselage in the way of the wing root, the rest in a 200 liter metal tank under the engine. The wing and tail surfaces used were the same as that described for the 1101 airplane. The He S-011 engine was located in the extreme tail of the airplane, balanced by the armament installation in the unusually long nose. Rather large C.G. travel was accepted as the ammunition was expended. This location of the engine gave a good jet exit, without requiring an extension tail pipe.

5. General.

(a) Power Plant Problems.

The success of the 1110 layout depends upon obtaining a satisfactory solution to the engine intake problem. Since the small fuselage precluded a fuselage nose entrance and the thin wing (plus main wheel stowage) prevented the use of a wing intake, the solution lay in the use of fuse-

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General. (a) Power Plant Problems (Cont'd.)

lage scoops. These chosen were of the semi-flush type, located at about 2 and 10 o'clock on the fuselage sides, above the after portion of the wing root. Boundary layer control, power induced, was considered necessary to make these scoops work. Two boundary layer suction slots were located on the inner surface of each duct, all four slots connecting to a common secondary duct which fed to a separate blower on the engine shaft. This blower raised the secondary flow to about the same pressure as that recovered in the primary flow at the engine entrance. The total air requirements of the engine were 24 cu. m/s (84.5 cu ft/s). Wind tunnel tests of a 1/2 scale model (at 50 m/s, 164 f/s) of the duct and boundary layer control system showed 1/3 of this flow (8 cu m/s, 28.3 ft/s) would have to go through the boundary layer blower in order to attain a total head recovery of 84% q in the remaining 2/3 (primary) flow. The blower power for this arrangement came out 200 shaft h.p. at sea level. Although the recovery in the primary flow was undesirably low, excessive blower power would be required to bring it up to the desired value of 95-98%. The deficiency in ram recovery gave a calculated thrust loss (as compared to that with the nose intake) of 8%. The 200 shaft h.p. to the blower lost another 4% of the thrust. The drag co-efficient of the airplane, however, was about 16% less than that of the 1101 or 1106 designs giving a net increase in V_{max} of about 2 1/2%, making the top speed of the 1110 design about 1015 to 1020 km/hr (630-635 mph). (NOTE: 620 mph at 23000 ft. given by Hornung - See Table I).

The rate of climb of all three (3) studies calculated to be 22 m/s (4330 ft/min.) at sea level and the service ceiling 14,000 m (46,000 ft). The O11 engine was expected to have an unusually good lapse rate, accounting of the high ceiling.

(b) Landing Gear.

The treatment of the main landing gear of the 1110 involved pivoting the oleo on the rear wing span, far enough outboard so that the wheel retracted inboard just inside the fuselage skin under the root trailing edge. The oleo leg housed within the wing. This arrangement gave considerably larger tread, and better provision for closing doors than that used on the 1101 and 1106. In order to make the wheel lie parallel to the fuselage skin, it was necessary to displace it with respect to its normal relation to the oleo strut. The method worked out to accomplish this motion consisted of a skewed extension of the wheel axle, at perhaps 30° to the axle, mounted on bearings in a fitting at the lower end of the oleo.

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General. (b) Landing Gear (Cont'd.)

The wheel-axle-extension assembly was rotated about the centerline of the extension by means of a separate hydraulic strut and linkage carried on the lower oleo fitting. By selecting the angle of skew and the amount of rotation about the extension centerline the desired stowed position of the wheel could be attained. The rotating linkage was locked on dead center in the extended position, so the whole structure could be made quite rigid against landing loads. (NOTE: Other drawings of the 1110 show a forward folding gear mounted at the side of the fuselage).

(c) Armament.

The gun used in these studies (and other recent German fighters) is a 30 mm. using explosive ammunition. The gun was designed and built by Rheinmetall-Borsig and is known as the MK 108. The barrel is unusually short and the muzzle velocity only 535 m/s (1760 fps). Voigt said that the trajectory is not bad in spite of the low velocity, because of the high ratio of weight to frontal area (drag) obtained with such a large projectile. The rate of fire of the guns in service was 660 round per minute. This was to be stepped up to 850 rds/m in June 1945 and the gun had been test-fired up to 1100 rds/m. German fighters used air to air rockets of about 2" diameter weighing about 4 1/2 pounds each. They were mounted on short rails with fins retracted. Close mounting prevented salvo fire because of interference between the fins of adjacent rockets. The bulletproof windshield (flat front) used in these studies was 90 mm. (4 in.) thick, set at about 30° to the flight axis. Refraction through this thick glass raised the effective line of sight about 60 mm. (2.4 in.) permitting the canopy top to be lowered by this amount.

(d) Longitudinal Trim Devices.

Voigt strongly favors adjustable stabilizers for longitudinal trim. His objection to tabs lies in a fear that compressibility separation will mask their air flow destroying their effectiveness when needed for dive recovery.

6. Summary of Me 1110 Design Study.

General - Single seat high performance fighter, arrow wing, conventional tail with high sweep-back and low aspect ratio, tricycle landing gear.

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Summary of Me 1110 Design Study (Cont'd.)

Engine - Heinkel-Hirth S-011. Weight dry 1900 lbs.

Static Thrust - 2860 first series, 3300 2nd series (without boundary layer blower).

Gross Weight - 9500 lbs.

Weight Empty - 6220 lbs.

Wing Area - 170 sq. ft.

Taper Ratio - .524 approximately (Construction tip chord divided by chord at centerline determined by prolongation of leading edge and trailing edge.)

Root Thickness - 8% parallel to plane symmetry.

Tip Thickness - 12% ll to plane symmetry.

Wing Sweep-back - 40° at 25% chord line (to be checked by flight test).

Armament - Three (3) 30 mm. guns with 80 rounds each. Weight of one (1) gun plus 80 rounds 245 lbs.

Fuel - type - Deisel, Sp. Gr. .82, capacity 316 gallons protected, 53 gallons unprotected.

Stalling speed - 110 mph.

Top Speed - 560 mph at S.L., 620 mph at 23,000 ft.

Service Ceiling - 46,000 ft. (for 100 ft/m rate of climb).

S.L. Climb - 4330 ft/min.

Span - 27 feet.

Overall length - 368" to jet, 407" to t. e. of rudder.

Fuselage Depth - over cabin 47", max. aft cab 44", Width 44"

C.G. Range - about 22%, small travel.

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Summary of Me 1110 Design Study (Cont'd.)

(NOTE: For practical purposes the 1101, 1106 and 1110 studies had identical wings and weights, so their performances differed only in high speeds).

High Lift Devices - Full span slots of constructed cross-section. Plain flaps.

Lateral Control - Conventional inset hinge ailerons, probably with hydraulic power boost.

Wing Location - Approximately 10 inches above bottom of fuselage.

NOTE: This design had boundary layer control, operated by a 200 h.p. blower on the engine shaft, to induce flow in the semi-flush engine intake ducts.

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II. TAILLESS STUDIES.

1. Introduction.

Tailless jet fighter studies, with arrow wings, were undertaken by Messerschmitt, January 1945, in an effort to obtain better engine air intake than were possible on the 1110 conventional tail design. Wing leading edge intakes were desired, but could not be used on the 1110 because of insufficient root section thickness. The increased area associated with the tailless arrangement made wing intakes possible, without exceeding the desired low root thickness ratio.

2. P1111 Development.

The first tailless study to take shape was given the model designation P1111. The fuselage arrangement had the main battery of two (2) 30 mm. guns in the extreme nose, with the nose wheel beneath, retracting aft. The pilots cockpit came next, and behind him the ammunition for an auxiliary battery of two (2) 30 mm. guns. This ammunition was fed under the air intake ducts to guns located in the outboard portion of the center section. The He-S-011 engine (2860 lbs. static thrust) occupied the after portion of the fuselage. A large swept-back fin and rudder were mounted over the aft portion of the engine. The wing had a short centersection, the leading edge of which blended into the fuselage in a sweeping fillet which contained the engine air entrance. The center section trailing edge was square with the airplane centerline and carried a flap which would probably be rigged upward for trim. The outer panel had 45° sweep-back of the quarter chord line, the leading edge being a continuation of the centersection fillet. Combination ailerons and elevators were fitted to the outer panel trailing edge, with possibly some flap inboard of the ailerons. Leading edge slots extended over the full span, including the portion occupied by the air intakes. The engine air intakes were elliptical in shape, located well outboard from the fuselage (to avoid boundary layer interference) and centered somewhat below the stagnation point for high-speed flight. Their area was rather large, giving an entrance velocity of 290 mph at rated rpm, according to Voigt. The landing gear oleo was pivoted on the after side of the outer panel main beam, at about 40% of the local chord. Retraction was inboard with the wheel lying partly in the fuselage, and partly in the wing root, at about 70% chord. The fuel system had not been well worked out, but it was intended to put the tanks entirely in the wing, principally in the outer panel. The P1111 had reached a stage of rather complete layouts and performance

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P1111 Development (Cont'd.)

calculations, and a proposal was submitted to the Air Ministry in March 1945. A summary of the dimensions, weights and performance of the Me P1101, P1110, and P1111 designs is given in Table I attached.

3. P1112 Design Study.

This study was intended to correct some of the objectionable features which became apparent as the P1111 progressed. The pilot was moved to the extreme nose of the airplane so that the nose profile blended into the windshield without any re-entry. The main battery of two (2) 30 mm. guns was moved out into the center section, with the ammunition in the fuselage feeding under the wing intake ducts supplying the engine. The wing area was reduced from 28.0 sq.m. to 22.0 in order to save weight, since it was felt that some increase in wing loading could be tolerated (the calculated stalling speed of the 1111 was only 155 km/hr compared to 178 km/hr for the 1110). Some increase in high speed was expected from the reduction in wing area, although the magnitude was questionable in view of the rapid rise of C_D vs M at the V_{max} of these airplanes. It was intended to get as much of the fuel as possible in the fuselage of the 1112, in order to obtain better shape and protection for the self-sealing tanks. Complete details were not worked out, but lack of fuselage space would probably have forced some of the fuel to remain in the wing. The remainder of the design closely resembled the P1111. Voigt said that he would have expected the P1112 to take preference over the P1111, unless further tests and calculation showed the speed gain to be negligible, in which case the lower stalling speed and better take-off of the P1111 would probably have justified its selection. Complete design studies and performance calculations on the P1112 had not been made at the time of the occupation

4. Future Plans.

According to Voigt, the Messerschmitt firm intended to proceed with the development of one of the models of single-jet-engine fighter described. At the time of the German surrender, however, no definite decision as to whether this airplane should be the convention-tail 1110, or one of the tailless studies, or both, had been reached.

Prepared by
J. M. Shoemaker, USNT

Table I

DATA ON LESSERSCHMITT HIGH PERFORMANCE SINGLE ENGINE JET FIGHTERS

(Data obtained from Hans Hornung at Oberammergau, Germany 27 June 1945)

A. DIMENSIONS

	P1101	P1110	P1111	Remarks
Wing Area (S)	15.85 m ²	15.85	28.0	Area includes area in fuze enclosed by projection of leading edge and trailing edge to airplane center line.
b	8.25	8.25	9.16	
A.R. = $\frac{b^2}{F}$	4.29	4.29	3.0	Construction tip chord divided by chord at centerline determined by prolongation of leading edge and trailing edge.
Taper ratio t	0.524	0.524	0.3	
Sweepback Angle 1/4 C line	40°	40°	45°	
Thickness (root)	.08 at .40C	.08 - .40	.08 - .40	
Thickness tip	.12 - .40	.12 - .40	.08 - .40	.40 means max. ord. at 40% C
Fuselage without Cabin:				
Depth	1.74 m	1.12 m	1.08	
Width	1.20	1.12	0.95	
Dia/length D/L	0.155	0.108	0.120	Dia of equivalent circle
Tail, Stabilizer and elevator	2.45m ²	3.0	---	
Fin and Rudder	1.4	1.8	2.0	
Wetted Area:				
Wing	26.5	26.7	49.0	
Fuselage	29.0	26.0	17.0	
Tail	7.7	8.6	4.0	
TOTAL	63.2	61.3	70.0	

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Table I

B. WEIGHTS

	P1101		P1110	P1111	
	Prod	Prototype			
Wing	450 kg	380	450	570	
Fuzelage (Body Group)	300	415	350	200	Including base fuze, enclosure, seat, floor
Tail Surface	90	121	90	50	
Controls	38	65	45	40	Including flap, aileron, rudder, elevator, and control mechanism (not slot)
Landing Gear Tricycle	230	293	230	230	
Total Airframe	1108	1275	1165	1090	
Powerplant Installation	986	806	1015	940	Including tanks, piping, engine controls. He S-011 base 840 kg. Ju 004 base 730 kg. approximately.
Equipment	190	110	190	190	(Not including armor or guns)
Armament Guns and Armor	310	350 (Ballast)	442	520	70 rounds, 60 kg. Weight of gun 70 kg. (MK 108)
Weight Empty	2594	2191	2812	2740	
Pilot	100	100	100	100	
Fuel	1250	829	1250	1250	
Ammunition	120		128	192	
Useful Load	1470	929	1470	1542	
GROSS WEIGHT	4067	3471	4290	4282	

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Table I

C. PERFORMANCE

Item	Prod P1101	P1110	P1111	Remarks
Engine	He S011	He S011	He 011	1300 kg. static thrust
V max.	100% 885 km/hr	95% 902 92% 882	96% 900	% figures are for estimated percent of rated thrust attainable in actual installation.
V max. H = 7 km.	980	96% 1000 92% 992	96% 995	
R/C S.L.	22.2	21.5	23.7	
Ceiling	Approx. 14000 m	Approx. 14000 m	Greater Than 14000 m	
Take off run	710 m	790 m	600 m	
V _S 1/3 fuel full ammunition	172 km/hr	178	155	
Landing run	570 m	610	450	
C _f = Skin friction coefficient without compressibility				Skin friction - C _f x wetted area x q
With slot	.00435	.00415	.00365	
Without slot	.00400	.00380	.0035	