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A LIGHTWEIGHT DURATION MODEL MONOPLANE

NEWNES

PRACTICAL MECHANICS

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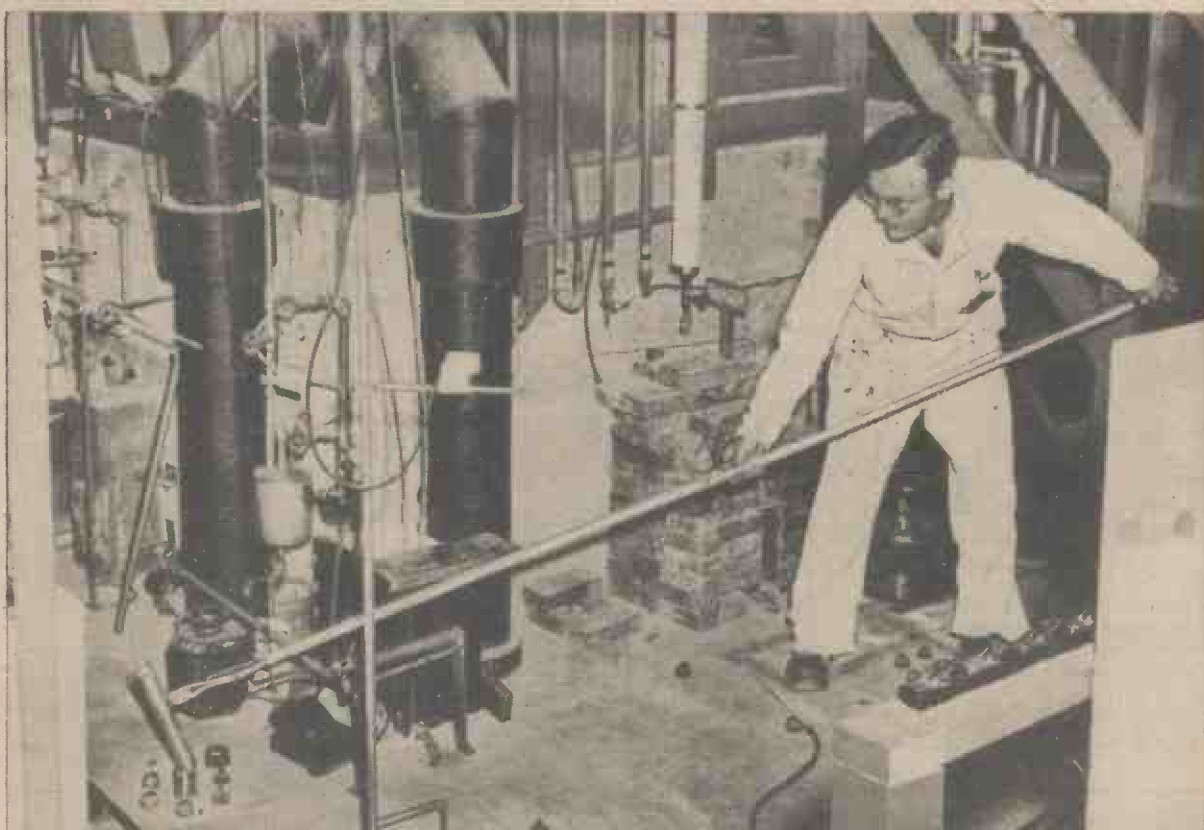


INSIDE AN ATOMIC BOMB FACTORY (See page 383)

The Ju. 8-263. This was a Messerschmitt project turned over to Junkers for development and manufacture: prototypes only were produced, the surrender bringing a halt to further work.

Rocket Propulsion

Rocket-powered Interceptors : Early Walter Bi-fuel Engines

By K. W. GATLAND

(*Continued from page 347, July issue.*)

THE autumn of 1944 saw another type of interceptor in action with the Luftwaffe, rocket powered and possessing phenomenal climbing ability. This was the Messerschmitt 163B, a tailless fighter which, including the time involved in take-off, took less than four minutes to reach a height of 40,000 feet.

Its outstanding performance under climb, however, was badly offset by a poor endurance. The period of flight under power at full throttle was little more than four minutes, and although it was possible to extend the actual flight duration by alternate bursts of power and gliding, the machine could not stay in the air for much longer than half an hour.

The fact that the Me.163B had a rate of climb seven or eight times greater than the best Allied fighters was no guarantee of its success. Its limited endurance did not permit sufficient time to make an effective interception, and certainly, once having flashed past the level of the bomber formations, there was little chance of challenging the target again. The aim, nevertheless, was to shoot up the formations during the almost vertical climb and, if fuel permitted, to circle above the bombers and attempt a second interception during a dive.

The tailless aeroplane pioneer, Dr. Alexander Lippish, is credited with the design of the Me.163, of which there were four versions: (a) trainer, 163A; (b) fighter—operational, 163B/O; (c) fighter—operational improved, 163B/1; and (d) fighter—development, 163C.

The machines of the 163 series were the first step in fighter design toward the ideal all-wing layout, and apart from the fact that each sub-type employed a slightly different power unit, the addition of a separate "cruising" motor and a pressure cabin in the 163C were the only principal differences. There were, however, slight variations in length and span.

The Messerschmitt 163B

It was the 163B versions that Allied pilots encountered over Germany, for the "C" sub-type did not proceed much farther than the prototype stage.

The fuselage was short and stubby, and the wings, which were set midway along its length, swept back at 23 degrees to compensate for the absence of a tail-plane. A single vertical fin with normal rudder control was fitted on the centre-line at the rear.

Of all-metal construction, the fuselage housed the rocket engine in the tail-end. The cockpit was placed about a third from the nose and was faired by a large "Plexiglas" moulded hood. At the rear of the pilot was the main oxidiser tank (containing hydrogen peroxide) which with two small self-sealing tanks in the cockpit gave a total capacity of 270 gallons.

The basic structure of the wing, main and auxiliary spars, was of wood. The covering was entirely dural and fixed slats, 7.17 feet in length, extended along the leading edge. Two split flaps of 7.73 sq. ft. area, with a minimum downward angle of 45 degrees, brought the landing speed down to 100 m.p.h.

The fuel, a hydrate-methanol solution totalling 130 gallons, was carried in two wing tanks.

The armament comprised two Mk. 108 30 mm. cannon mounted in the wing roots which each fired 60 rounds, and the pilot was protected by 15 mm. armour plate at front and rear, the nose of the machine consisting of a detachable cone of armour.

A heavy metal skid was fitted for landing and this retracted into a fairing beneath the fuselage. There was also a small retractable tail-wheel which interconnected with the rudder for taxying the 'plane in conjunction with wheels fitted to the skid. These main wheels were also used in take-off, being jettisoned once the machine was airborne.

The electrical services were supplied by a 2,000 watt "windmill" generator fitted in the centre of the armoured nose.

The instruments, which were carried on normal type "dashboard" panels, covered a fairly wide range and included an altitude-compensated air-speed indicator, rate of turn indicator, and all normal navigational equipment. The power unit registered on a composite accelerometer/thrust indicator, and there were other instruments which recorded the fuel feed pressures and tank capacities. An indication of low level in the tanks was given by red warning lights, and a fire warning device was also fitted.

Controls

The thrust of the HWK 109/509A1 engine of the Me.163B/O was controlled by a throttle fitted on the port side of the cockpit. There were five settings, "Off," "Idling," and three stages of power ranging from 220lb. thrust in the lowest gate to 3,520lb. at the maximum setting.

The necessity of providing a composite aileron/elevator control in the wings made the design of the flying control system somewhat unorthodox. In full lateral movement, the control column operated the composite aerofoils (these are known as "elevons") as ailerons. A true longitudinal movement functioned them as elevators, while diagonal motion of the column brought about the operation of only one elevon effecting roll and pitch.

Performance

The machine flew at a maximum speed of 515 m.p.h. at sea-level, while at heights greater than 13,000ft. this figure was increased to 558 m.p.h. Although there was apparently no great difficulty in its control, the pilot had nevertheless to keep a careful watch on his air-speed indicator, as any too violent acceleration around the 550 m.p.h. mark was likely to initiate a sudden downward pitch.

A run of a little more than 700 yards was required in take-off to gain 65ft., and the 'plane climbed away at approximately 450 m.p.h., reaching a height of 20,000ft. within 3.04 minutes. The maximum ceiling was reached at 40,000ft. after 3.98 minutes, further altitude being impossible because the cockpit was not pressurised.

The leading dimensions of the "B" sub-types were as follows: length, 18.7ft.; span, 30.5ft., and the overall height, 8.2ft. The gross wing area was 211 sq. ft.; the wing loading at take-off, 42.9 lb./sq. ft., and at landing, 21.9lb./sq. ft.

The Messerschmitt 163C

The 163C version embodied a cruising motor in addition to its main rocket engine, and this, the HWK 509 A2, was found to be much improvement on the single HWK 509 A1 and HWK 509 B units of the earlier sub-types. It developed a maximum thrust of 3,970lb., plus 660lb. from the auxiliary unit. The endurance under full throttle was raised to 12 minutes, the operational ceiling to 52,500ft., and the time entailed in reaching 40,000ft. was an improvement of 96 seconds on the climb of the 163B/O. Its maximum flying speed was approximately 600 m.p.h.

The machine carried 5,570lb. of propellant, and the addition of the cruising motor and pressure cabin put the all-up weight at 11,300lb.

In an effort to further improve the range and endurance, the fighter versions were, on occasions, towed up to interception height behind orthodox fighters. This was not the usual practice, however, as the prime utility of the 'plane was in its ability to climb from the ground and reach combat height almost within sight of the oncoming formations. It was essentially a fighter for the defence of specific targets and normally could not be expected to patrol.

ROCKET ENGINE	PROPELLANT	PERFORMANCE thrust—min. to max.	APPLICATION
R11/203	"T" and "Z" stoff	220lb. to 1,650lb.	Me. 163A
HWK 109/509 A1	"T" and "C" stoff	220lb. to 3,520lb.	Me. 163B/O
HWK 109/509 A2	"T" and "C" stoff	220lb. to 3,970lb., plus 660lb. (cruise)	Me. 163C
HWK 109/509 C	"T" and "C" stoff	220lb. to 4,400lb., plus 880lb. (cruise)	Ju. 8-263

Table I. Power units of the Messerschmitt 163 series.

The Trainer Version

The training of pilots was made in a lower-powered version of the fighter, the 163A.

A development of the HWK 109/500 Walter assisted take-off motor (PRACTICAL MECHANICS, March, 1946, p. 209), the R11/203, was fitted in the trainer, and propulsion was by the reaction of H_2O_2 and calcium permanganate. The maximum fuel capacity was approximately 3,300lb., which gave the machine an endurance under power of a little more than three minutes, and a 20,000ft. ceiling. The thrust was controlled through a normal type throttle box, from 220 to 1,650lb.

The Ju. 8-263

A little higher in the scale of development was the Ju.248, a single-seat rocket fighter similar in conception to the Me.163C. The machine was, in fact, a development of the 163 series, but had been handed over to Junkers for production to allow Messerschmitt to go ahead with no fewer than eight other project aircraft, chief amongst which was a new version of the Me.262 fitted with a Walter rocket unit in the tail.

A close-up of the retracted landing-skid and jettisonable take-off chassis of the Messerschmitt 163B.

The 248 was later reclassified 8-263 to obtain consistency with the original series. Several improvements considered desirable from the standpoints of production and operation were incorporated, and although the machine bore a strong resemblance to its forebears, it had been cleaned up aerodynamically by the provision of an entirely redesigned fuselage.

The incorporation of a retractable undercarriage eliminated the bulky landing skid and tail-wheel fairing which made the 163's appear clumsy, and this resulted in a well-faired fuselage, the contour of which was smooth and unbroken save for the " bubble " hood placed near the nose. Of semi-monocoque construction, the fuselage fitted a pressure cabin and housed most of the propellant. There were three tanks for the peroxide oxidiser which totalled 352 gallons, while the fuel tanks, containing 185 gallons, were divided, one in the fuselage and four in the wings. In order to ensure a minimum change in the position of the c.g., it was necessary for the tanks to be emptied in a particular order.

Production was facilitated greatly by the use of 163B wings, suitably modified to take the increased fuel load, while the fin and rudder were also standard assemblies of the 163 series. The switchover to the 8-263 would, therefore, have involved no great loss in output.

Apart from the engine these were the principal differences. The HWK 109/509C, developing a maximum thrust of 4,400lb. plus 880lb. from the cruising unit, gave the machine a maximum speed of 620 m.p.h. in level flight. It climbed at the rate of 13,800ft. per minute at sea level, reaching its ceiling at about 50,000ft.

The machine had an all-up weight of 11,340lb., which was reduced to 4,640lb. by the consumption of the propellant. Its overall length was 26ft., and the wing span 31.2ft., an increase over that of the 163B caused by the greater width of the fuselage.

The wing loading was 59.4lb./sq.ft. at take-off, which naturally reduced with the combustion of the propellant. At the time of landing with tanks empty, the figure was 24.2lb./sq.ft.

The engines which propelled these aircraft hold much promise for development in conjunction with athodyd units of the type described in the previous article, and by far the most important were those of the HWK 109/509 series (see Table 1).

The Walter Bi-fuel Propellants

Commenced in pre-war days as a private venture, the HWK 109/509 engines were developed by Dr. Walter, of Kiel, being the first fully controllable rocket power units ever to be employed in flight.

It will be recalled that in every case of experiment with liquid fuels before the advent of the Walter units, the oxidiser had always been liquidised oxygen. In service aircraft, however, the use of liquid oxygen would present several difficulties, for although when burned in conjunction with a suitable hydrocarbon it is capable of releasing tremendous energies, the low temperature at which it liquefies (−182.9 deg. C.) means that extreme care must be taken in its storage, transport and handling.

When contained at normal temperature in anything other than a "Thermos" or Dewar storage bottle, it is rapidly reconverted into gas, and unless the tank is pressurised and relief valves are incorporated, there is every possibility of the mounting pressure causing a violent explosion.

These difficulties are not easy to overcome at the best of times, and when a fighter aircraft is considered, which has to be fuelled some time before it actually takes off, the problems become almost insuperable.

Another important factor concerns the materials used in the construction of the tank and feed system, which must be carefully selected as many metals change their physical characteristics at such low temperatures. There are many accounts on record telling of experiments which have been completely ruined by the disruption of the containing tanks and feed lines by this highly volatile liquid.

It was for these main reasons that the Germans strove to produce an entirely new oxidising agent—one that could be handled without overmuch caution by Luftwaffe ground personnel. The V-2 rocket was, of course, a fundamentally different matter, because fuelling and launching took place within a specified time and the weapon was operated by specially trained crews. The use of liquid oxygen, even then, was nothing like 100 per cent. reliable, and several of the missiles exploded as the result of a too vigorous expansion of the oxidiser.

Hydrogen Peroxide

The investigation of various propellant forms involved the German chemists in research for several years, and four oxidisers—gaseous oxygen, nitrous oxide, nitric acid, and hydrogen peroxide, were eventually put forward as the most suitable for rocket-powered interceptors and guided missiles. A further elimination after extensive tests established hydrogen peroxide as the oxidiser for the Me.163, Ju.8-263, Bachem Ba.349, etc., and it was also employed as an auxiliary fuel for the turbine-pump feed in the V-2, as well as in the rocket fighters.

The substance had not been previously considered by rocket experimenters because it had hitherto not been available in sufficient concentration. Its production at 80 per cent. purity was certainly a great achievement and brought full justification to Walter's theories. Actually, the Germans had succeeded in the purification of the liquid to over 90 per cent. strength, but in this state it was found to be dangerously unstable. The compromise, therefore, was *concentration* with a reasonable safety factor; yet, despite this, Me.163's often blew up.

The fuel component in the case of the HWK 109/509 engines was a solution of 57 per cent. hydrazine hydrate, 30 per cent. methanol and 13 per cent. water.

When brought together in the combustion chamber, the two liquids undergo a violent and spontaneous combustion; there is no

CODE	COMPOSITION	APPLICATION	
		In Conjunction with:	For:
A-stoff ..	Liquid oxygen	Ethyl alcohol	
Benstoff ..	Ethyl alcohol	A-stoff	A-4 long-range rocket
C-stoff ..	57 per cent. methanol, 30 per cent. hydrazine hydrate, and 13 per cent. water	T-stoff	Me.163 fighter series—main propellant
T-stoff ..	80 per cent. hydrogen peroxide	C-stoff	
Z-stoff ..	Saturate aqueous solution of calcium (or sodium) permanganate	T-stoff	Walter A.T.O. units; A-4—as turbine generator for fuel pumps; Hs. 293, and Me.163A
Salbei ..	98 per cent.—100 per cent. nitric acid	Tonka, Visol, Petrol J-2, Diesel oil, etc or C-stoff	Wasserfall, B.M.W. rocket engines, etc.
Tonka 505b	57 per cent. oxide-m-xylidine	Salbei	B.M.W. engines
Tonka 505c	43 per cent. triethylamine	Salbei	B.M.W. engines
Visol ..	Butyl ether (with 15 per cent. aniline)	Salbei	Wasserfall, Enzian, etc.
J-2	Coal oil	Salbei, etc.	Various jet and rocket engines
—	Gaseous oxygen	Methanol	Alternative propellant for Hs.293, etc.

Table 2.—Details of some of the main propellants used to power German rocket fighters and missiles.

ignition in the normal sense, the propulsive gases resulting from purely chemical reaction. All rocket engines which operate on this principle are termed "cold" units to distinguish them from the earlier "fuel-burning" types.

A list of the principal fuels and oxidisers used in fighters and missiles is given in Table 2, and it will be seen that the peroxide oxidiser was known by the code, "T-stoff," and the fuel solution, "C-stoff."

First Experimental Walter Engines

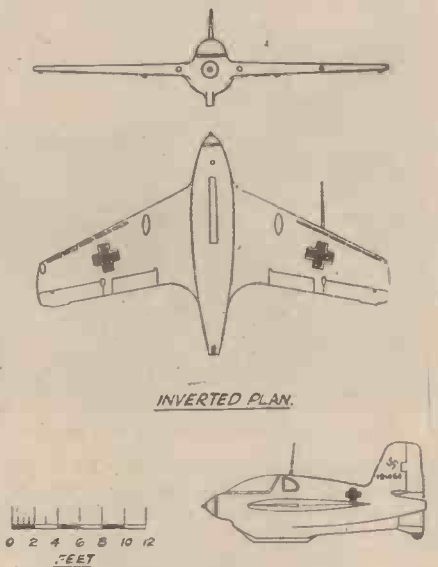
The Reichsluftfahrt-Ministerium assigned the designation 109 to all important jet and rocket engines, the second figure indicating the type and specific model. Thus, numbers in the second group between 001 and 499 inclusive applied to jet motors, whilst those from 500 to 999 were allotted to rocket units.

The first experimental engine of the 163 series was built in June, 1941—an air-cooled variable-thrust unit embodying a H_2O_2 turbo-pump feed system. Its fuel developed a maximum thrust of 1,650lb. for a specific consumption of 36lb./lb. thrust/hr.

This was the forerunner of the HWK 109/509.A1 employed in the Messerschmitt 163 B/O, which went into production with very little alteration to the original design. There were, of course, several lesser offshoots of this development which evolved in the shape of propulsion units for aerial missiles, auxiliary power units for gliders and assisted take-off motors. It will be recalled that the initial use of a bi-fuel unit of the "cold" type was in the Henschel 293 anti-shipping "glide-bomb," first operated during the summer of 1942.

Two main problems confronted Dr. Walter when he first set out to productionise his engines.

The first concerned the building of a combustion chamber capable of withstanding temperatures up to 2,000 deg. Centigrade, and in this, the designer was tackling a problem which had hitherto been only partly solved by earlier researchers. It is true that Sänger, and the Americans, Carver, Truax and Wyld, had developed some promising liquid fuel motors in which, by various refinements, the possibility of burn-out had been very much reduced, but they were, nevertheless, hardly comparable with the large-scale engines that Walter had in mind. In any event, the motors produced by the American Rocket Society could not stand up to repeated firings, and few were capable of withstanding combustion at full thrust for more than 30 seconds. It was, in fact, often the case that motors were so damaged after one firing that they had to be entirely rebuilt before it was possible to test them again.



The Messerschmitt Me. 163 B.

It was obvious that for a service aircraft, which perhaps may be called upon to fly off to intercept several times during a single day, a motor would be required to operate for quite lengthy periods without need for extensive servicing or replacement. The development of rocket fighters would certainly not have been considered had it not been possible to produce a power unit able to be operated at full thrust for 30 minutes without deterioration.

It was fortunate for Walter that the development of the V-2 long-range rocket (otherwise known as the A-4), under von Braun, had involved similar research. A great deal of data on combustion systems had been amassed since the commencement of the "A" series in 1933, and this must have been of immense value to the designers of the Me. 163. It is, in fact, not unreasonable to assume, from the similarity of the power unit of the A-4 and the HWK 109/509, that the two engines were basically a parallel development.

The A-4 had, too, involved a great deal of research with feed systems, and it would seem that this was largely the solution to Walter's other principal headache, borne out by the fact that the H_2O_2 turbine driven pumps in the HWK engines were of an almost identical pattern to those employed in the long-range rocket.

(To be continued.)

Electro-mechanical Differential Analyser

A 100-ton Calculating Machine

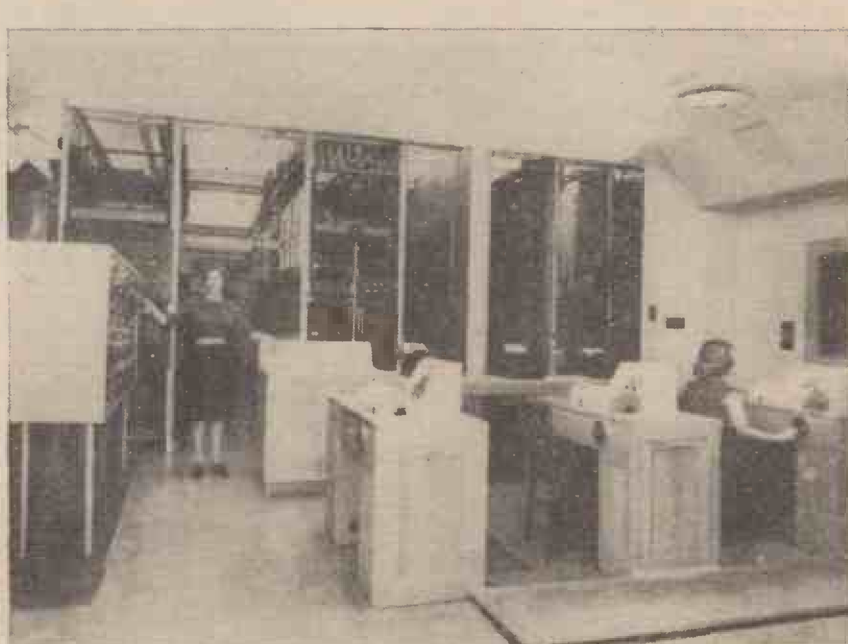
THE illustration on this page shows an electro-mechanical differential analyser, a 100-ton calculating machine installed at the Massachusetts Institute of Technology in America. It was designed for the solution of scientific and industrial engineering problems and worked for three years on important war projects which included computation of range tables for the guns of the U.S. Navy.

Peacetime Problems

Its wartime service now over, the machine has now turned to its original objective, the solution of peacetime problems in a field of usefulness which includes every branch of science and engineering. The panels in the background contain approximately 2,000 electronic valves, several thousand relays, about 150 motors, and nearly 200 miles of wire. In front of the panels are automatic electric typewriters which record numerically the solution of complex differential equations, while in the foreground graphic solutions are drawn in the form of curves on revolving cylinders.

Transmitting Devices

At the left are transmitting devices through which mathematical data is introduced to the machine on perforated paper tapes. The analyser not only relieves human brains of the time consuming drudgery of difficult calculation and analysis, but solves mathematical problems which are economically beyond the reach of ordinary methods of solution.



This machine is capable of solving mathematical problems which are economically beyond the reach of ordinary methods of solution. Invaluable during wartime this machine is now used for solving intricate peacetime problems.