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SOME GERMAN AIRCRAFT ARMAMENT PROJECTS

with particular reference to

FIRE CONTROL DEVELOPMENTS

BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

SOME GERMAN AIRCRAFT ARMAMENT PROJECTS

With particular reference to FIRE CONTROL DEVELOPMENTS

Reported by F/Lt. M. O. ROBINS M.A.P. (R.A.E.)

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

32, Bryanston Square, W.1.

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Personnel of Team

H. L. Stevens, Deputy Director, R.A.E.
M. O. Robins, Fire Control Division, R.A.E.

Scope of Report

This report concerns airborne fire control equipment and related subjects. It is written as a result of a 14 day visit to Germany, and has no claim to cover the subject completely. It contains little information not already dealt with in some detail in reports listed at the end, but attempts to summarize what is considered to be most valuable for the subject under review.

Acknowledgment is made of the help received from the work of earlier investigators. (Refs. 1, 2, 3, 4).

Summary

Of the establishments visited, the most valuable information was obtained from the Weapons Institute of L.F.A. Volkenrode.

The work of this Institute included projects for fighters such as upward and downward firing armament, and stabilization as an aid to gun aiming; theoretical and experimental ballistic work relevant to air firing; measurements and research on automatic guns. The equipment was generally on a lavish scale perhaps not matched by the results achieved.

Investigation of the work continues. The stabilization project for fighter armament probably has the most potential value from the fire control point of view.

The remaining targets visited were of less direct interest, and their main work has been expertly described elsewhere. Gun developments at Rheinmetall Borsig, Unterlüss, and ammunition and rocket developments at D.W.M., Lübeck, were of interest.

Luftfahrtforschungsanstalt Herman Göring, Volkenrode Brunswick - Target C2/662

1. The L.F.A. was visited for a week, commencing September 13th 1945.

1.1. The institute was under the directorship of Prof. Blenk. He was responsible to the Forschungsführung under Prof. Georgii, and thence to the German Air Ministry. L.F.A. was constituted as follows:-

Aerodynamic Institute.
Structures and Materials Institute.
Engine Research Institute.
Weapon Research Institute.
Central Workshops.

The total staff of L.F.A. totalled about 1,500, of which 150 were university graduates. About 20% of the total effort was devoted to the Weapons Institute.

The majority of the buildings were completely hidden in woods, covering about 4 square miles, and well camouflaged. The institutes were undamaged by air attack, but much valuable portable equipment had been looted. The scale of the equipment, in quality and quantity, in both laboratories and workshops, was most impressive.

1.2. The head of the Weapons Institute was Prof. Rossman, who came from Krupps in 1942, and was mainly interested in artillery and related ballistic problems.

Three divisions under Rossman were headed by:-

Dr. Hackemann, who was mainly interested in the internal ballistics of guns, and the stabilization of fighter armament.

Dr. Schüssler, who was concerned with a 30 metre cross wind tunnel, and a 400 metre variable air density tunnel, for projectile ballistic work.

Dr. Schugt, who was mainly concerned with bombsights and anti-aircraft sights.

Further details of these scientists are given in the appendices.

2. Fighter Armament Projects

The arming of fighters was given relatively high priority with the growth of the Allied bomber menace to Germany.

The arming of bombers was given low priority, owing to the rapid decline of the German bomber force, and to the little faith in the future of armed bombers expressed by most German authorities. Dr. Hackemann was directing both a short term and a long term fighter armament project.

2.1. The short term project was called S.G.116 and involved fitting a battery of "recoilless" guns, firing upwards. The orthodox pursuit curve attack against a heavily armed bomber was too dangerous, so a head on attack in which the fighter passed underneath the bomber was contemplated. A ripple salvo of projectiles was to be fired upwards from the fighter as it passed below the bomber at a range of 50 to 100 metres. The firing was to be automatic, detection of the target being by an infra red photoelectric device which would operate in day and night conditions.

It would be difficult for the fighter to establish a near collision course with a bomber taking avoiding action, but if this were achieved, the chances of success were considered to be high, owing to the large plan area presented by the target and the short range.

Several prototype installations were commenced. Firstly, 20 mm spin stabilized projectiles of low muzzle velocity; one shot was to be fired from each of 100 barrels. The instability of these projectiles in the short range led to the use of fin stabilized projectiles, having a muzzle velocity of about 150 metres/sec. Tests in the cross wind shooting tunnel had shown that these projectiles were in stable flight in less than 100 metres.

The final arrangement contemplated for the F.W.190 comprised 3 x 5 cm calibre guns in each wing.

2.2. An armament of a rather similar nature called SG.113 was under development for attacking tanks. To avoid A.A. fire as far as possible, the fighter would fly in very low, and to benefit by the thinner armour on the top of the tank, would fire downwards, with guns fixed in the aircraft. In prototype arrangements, 6 tubes were mounted nearly vertically in the fuselage each firing a 4.5 cm shell downwards, with muzzle velocity 750 metres/sec. Recoil was taken by a heavy iron plug projected upwards. Firing of the guns was to be automatic when the aircraft passed over the tank at a height of about 10 metres.

Several automatic detection devices were under development:

(a) An electro static device which detected distortion of the earth's field by the tank; this device was susceptible to the ground contour and to weather conditions.

(b) A radar detector.

(c) A magnetic device which detected distortion of the earth's magnetic field by the tank.

Device (a) was fitted to 3 H.E.129's and to 3 F.W.190's, but so far as is known, this armament was not used operationally.

These two projects may well have achieved some success, and defences against this type of attack should be considered.

2.3. A longer term project of a more fundamental character, a stabilized armament for fighters, was under development by Hackemann; the work was in an early stage of development. While considering that the ultimate main armament of a fighter may be homing missiles, it was thought that long range gunnery for the attack of bombers was likely to be important for some considerable time.

For the successful attack of a bomber by gunfire from a fighter, large calibre shells must be fired from long range, e.g. 50 mm shells from ranges between 1000 and 2000 metres. Success would depend on accurate aiming, which would demand accurate and smooth tracking of the target.

Hackemann considered that good tracking could not be achieved in a high speed fighter with orthodox controls. He proposed a system of stabilization along the following lines:-

A single gyro was to stabilize the gunsight graticule, and provide rate of turn information for lead computation.

This same gyro could also stabilize the guns, or alternatively stabilize the complete aircraft through automatic controls. It was not intended to stabilize against bumps, but rather against oscillations of about 5° total amplitude, and of period about 3 secs.

Some experiments had been made:-

A gyro was mounted in a Me.210, its rotation axis being parallel to the aircraft longitudinal axis.

A sighting graticule was reflected from a mirror attached to the gyro. The gyro could be processed electro magnetically by currents in control coils. These currents were controlled by movements fore and aft and transverse, of a simple joystick. A ciné camera in a suitable mounting was remotely controlled from the gyro.

Thus by moving the joystick, the operator could aim the graticule and camera, both of which were stabilized by the gyro.

The aircraft was flown with the pilot aiming at a target with a fixed reflector sight; a camera recorded his aiming errors. At the same time, the observer aimed at the target with the stabilized graticule, and the stabilized camera recorded aiming errors of the guns it was replacing.

The records of these experiments were no longer available, but it was claimed that the aiming errors of the observer were smaller than those of the pilot, by a factor of several times. The equipment used for these trials had been despatched to U.S.A.

2.4. Dr. Hackemann was questioned on the general problem of fighter versus bomber, as it may develop in the coming decade. His theme was that well armed fighters would be essential, to force an enemy to rely on guided missiles rather than on the more accurate, but more vulnerable, piloted bombers. He thought that fighters, armed with long range guns and predictor sights for attacks at 1000 to 2000 yards range, and possibly with homing missiles for longer range attacks, would defeat piloted bombers.

Dr. Schugt considered that the piloted bomber would not succumb to fighters, but produced no convincing arguments to support his theory.

3. Exterior Ballistics, Theoretical

A group at L.F.A., under the direction of Prof. Doetsch dealt with external ballistic problems arising in air to air firing. The writer did not obtain first hand information on this subject as the whereabouts of Prof. Doetsch were unknown, but the following gives the type of work on which apparently, he was engaged.

(a) The production of air firing tables based on measurements of velocity and time of flight.

(b) The probability of destruction of a target in air combat, and hence the relative effectiveness of weapons.

(c) "No deflection" shooting from aircraft.

(d) Curves of pursuit and lead angle calculations.

(e) Practicable zones for air combat.

(f) General tabulation of ballistic functions.

4. Exterior Ballistics, Experimental

This work was in the charge of Dr. Schüssler; he was not available for interrogation, but information was obtained from his assistant, Dr. Siegman.

Work was concentrated in the two major "shooting tunnels", viz:

(a) The 400 metre tunnel, equipped with cameras for projectile photography, and which could be exhausted to an air density corresponding to a height of 30 Km. The primary purpose was to study the stability of projectiles.

(b) The 30 metre cross wind tunnel, in which projectiles could be fired into a cross wind, of speeds up to about 200 metres/sec., and examined for stability over a range of 30 metres.

Work in these tunnels had been of a short term war time nature. When examined, the tunnels were little more than concrete shells, apart from the evacuation machinery. All the cameras and spark photography equipment had been stripped.

4.1. The tunnel (a) consisted of an underground firing range whi was 400 metres long. The cylindrical cross section varied from 5.4 to 7.6 metres in diameter. The range including the room containing the gun, could be evacuated to 0.02 atmospheres, corresponding to a height of about 30 Km. The external seal was of copper sheeting, and leakage was claimed to be no more than the equivalent of a 1 inch diameter hole.

Evacuation by a 3 stage pump system, consuming about 540 KW required between 3 and 6 hours.

Photography of the projectile during its flight down the range took place at several stations. Only 8 stations had been used, but it was intended ultimately to have 50.

Each station comprised a triggering device, spark illumination and two plate cameras. The triggering device was a screen of two sheets of aluminium foil, separated by an insulating layer, which gave an impulse to a thyratron circuit and hence to the spar when punctured by the projectile. The spark units or "blitzgebers each gave 3 sparks in succession at 1 millisecond intervals, so that 3 photographs of the projectile were obtained on each plate of each camera. It was said that ordinary plate cameras were use one mounted in the tunnel roof, and the other in the side, so that from the two photographs, the position of the projectile in space could be determined accurately. The times of the sparks were recorded on an oscillograph with a tuning fork time base.

It was claimed that the position of a projectile could be located to an accuracy of 1 millimeter, the orientation to 0.2° fc a projectile 2.5 cms long, and time to $\pm 10^{-6}$ secs.

Little or no fundamental ballistic work seemed to have beer done in this tunnel, owing to short term war requirements. Projectiles of calibres up to 88 mm had been fired in the tunnel. It was said that the rather primitive method of triggering the sparks was to have been replaced by more elegant photoelectric equipment, using multiplier cells instead of the usual single cells and electronic amplifiers.

The size and evacuation aspects of this tunnel were impressive.

4.2. Tunnel (b) was of unusual design, intended for investigatic of trajectories and stability when a projectile was fired into a strong cross wind.

The range of roughly rectangular cross section was about 30 metres long, and 1 metre wide; the top was open to the atmosphere for its whole length. The range was connected by a series of 10 aluminium windows to a large cylindrical chamber, volume about 3000 cubic metres; which was parallel to it, and which could be evacuated. The aluminium windows could be blown out simultaneously by a primer cord, thus opening the evacuation chamber to the atmosphere, via the range. The inrush of air to the chamber was the cross wind through which the projectile was fired. The velocity of the air across the range could be regulated by a series of rollers which impeded the flow.

It was claimed that a maximum cross wind velocity of 150 to 200 metres per second could be maintained substantially constant for 0.5 secs.

Apparently only brief checks of air flow velocity and uniformity had been made, by taking high speed photographs of a shower of small pieces of paper released in the air stream. Spark photography, by several pairs of cameras, taking shots at right angles, was achieved through windows in the side of the range.

There has been no timing or triggering equipment specifically for this range.

This tunnel was not completed until 1944, and it was said that only one type of projectile had been tested in it, namely the low velocity fin stabilized projectiles proposed for use with the upward firing fighter armament described in 2.2.

Owing to the almost complete lack of calibrations and measuring equipment, considerable effort and time would now be needed to obtain data from these ranges.

4.3. It was proposed to utilize the evacuation chamber of the cross wind range in a small intermittent wind tunnel. The working section would be connected to the evacuated chamber through an aluminium window which would be blown out by a primer cord, causing an inrush of air through the working section. It was intended to test the effectiveness of strikes on aircraft wings etc. in an airstream, in this wind tunnel.

4.4. A Me.110 aircraft fitted with a Mk.108 gun in the nose, at an angle of about 20° elevation to the longitudinal aircraft axis, was inspected. This had been used apparently, to check theories of "no deflection" shooting.

5. Internal Ballistics and Weapon Research

A considerable amount of work under the direction of Dr. Hackemann included the following main items:-

5.1. Development of a piezo electric gauge for the measurement of force, having a highly linear response for both tension and pressure.

5.2. Development of a technique for recording the motions of parts of automatic weapons. In principle, a "triple mirror", which reflects light along the line of the incident light, was mounted on the moving part, and the reflected light beam recorded on a photographic film.

5.3. Measurement of the temperature at the surface of the bore of a gun, by means of a very small and elegant nickel steel thermocouple inset in the wall of the gun barrel.

It was said that results of gun temperature measurements showed that it should be possible to increase the rate of fire much above the present accepted rates without overheating. A rate of about 1600 rounds per minute was claimed for some aircraft guns.

5.4. Research on the stress in an aircraft produced by the recoi of a machine gun.

5.5. Development of a piezo electric accelerometer for use in aircraft; the response, in one direction only, was claimed to be linear up to 40g. The recording was by mirror galvanometer oscillograph.

6. Rheinmetall Borsig, Unterlüss, Target 2/26

6.1. A very short time was spent at this target, which was badl damaged.

The establishment comprised the artillery proving ground : the firm, and several departments including:-

Department WKF	Research.
Department WKW	Weapons.

The target was in the charge of Ministry of Supply repres tatives, and was being exploited by them.

Director Herlach and Dr. Braun were interrogated on airc armament fire control topics.

They considered that the best weapons for fighters, vers bombers, would be 55 mm guns, firing H.E. projectiles. The be bomber weapons would be 30 mm guns, for defence against fighte The best form of sight would probably be a development of the EZ.42 type of gyro gunsight.

Relevant work at Unterlüss had been the development of the 3 cm Mk.103 and Mk.108 aircraft guns.

A 55 mm aircraft gun, with a muzzle velocity of 600 metres/sec. was under development.

6.2. Experimental Station at Fassburg, near Trauen. C2/773

A brief inspection of a small station for testing the thrusts of rocket motors was made; the station was on the outskirts of Fassburg airfield and was being exploited by the Ministry of Supply.

The German in charge was Dr. Grumbt.

A thrust balance capable of measuring up to 100 tons was seen. Rocket motors using diesel oil and liquid oxygen as fuel and zinc diäthyl as ignition agent were tested here; there was a liquid oxygen plant (Linde process) capable of producing 1500 Kg per day for experimental purposes.

7. Walter Werke, Kiel. Target 2eii/63(b)

7.1. A short inspection was made of this target, which was being exploited by the Admiralty and M.A.P.

The work was largely research and development of rocket motors operated with hydrogen peroxide, and has been expertly described elsewhere. Ref. 6.

Armament applications of Walter rocket motors included the guided missiles "Schmetterling" and "Enzian", and the piloted missile "Natter".

8. Blom and Voss, Hamburg/Finkenwarder. Target 25/3

8.1. This target, an aircraft factory, occupied by military forces, was briefly inspected.

Little of armament interest was found, and most equipment of value was crated prior to evacuation.

There was a small open jet wind tunnel, working section about 5 ft. in diameter, having a maximum air speed of about 150 ft./sec.

The BV.246 glider bomb was made at this factory, and parts were examined.

9. D.W.M. Lubeck, near Schlütup. Target 2/22

A brief visit was made to this target, which was occupied by military forces and appeared to be undamaged. For comprehensive information on this target, see Ref. 5.

9.1. The factory was concerned with the development and production of ammunition and weapons. Equipment and facilities such as open ranges seemed to be of high quality, and included a test chamber for temperature tests on fuzes and propellants down to -80°C.

9.2. Ammunition developments for aircraft weapons included:

(a) 15 mm ball ammunition of solid steel, with a copper driving band (necessitated by lack of lead).

(b) 30 mm H.E. ammunition, using 90 grains of explosive. It was estimated that an average of 4 hits was required to bring down a Fortress.

(c) For the production of artificial fog, rounds filled with a mixture of titanium tetrachloride and silicon tetrachloride were used.

9.3. Rocket developments, primarily for air to air firing included:

(a) The RZ.65 spin stabilized rocket 7.5 cm calibre.

(b) The R4M fin stabilized rocket, 5.5 cm calibre.

The R4M was favoured because of its smaller dispersion. This rocket had eight fins which were folded close to the body f stowage purposes. The fins opened out immediately after launch aided by spring loading and a small spoiler plate on the end of each fin.

The rockets were rail launched from a mounting board whic also served as a transit case. In the case of the Me.262, one board, mounting 12 rockets, was to be fitted under each wing. rockets would be fired in a ripple salvo, each one tripping the next. After firing the mounting boards were to be jettisoned.

References

1. Report on C.I.O.S. Trip 462 by Col. Hinds, A.R.D., Ministry of Supply.

2. Report of Special Mission on Captured German Scientific Establishments, L.F.A. (C.I.O.S.) Target 25/71,
by Col. L. E. Simon,
Ord. Dept., U.S. Army.

3. Armament Projects at L.F.A., Völkenrode, by S/Ldr. R. F. Fisher, R.D.Arm.3(b), M.A.P.

4. Armament Work at L.F.A., Völkenrode, by Mr. L. G. Carpenter, General Arm. Division, R.A.E.

5. Report on C.I.O.S. Trip 209, to D.W.M., Lubeck by Col. Dixon, C.E.A.D., Swynnerton.

6. Walter Rocket Motors for Aircraft. R.A.E. Tech. Note No. 1668.

Walter Experience with hydrogen peroxide and related chemical and metallurgical features. R.A.E. Tech. Note No. 1669.

Walter Rocket Motor testing technique and equipment. R.A.E. Tech. Note No. 1670.

Investigation of Walter Werke, Kiel. R.A.E. Tech. Note No. 1667, by A. D. Baxter.

APPENDIX A

Prof. Dr.-Ing. Th. Rossmann
Director of the Institute for Weapons Research of the L.F.A.
(Luftfahrtforschungsanstalt) Braunschweig

Outline of career previous to activity at L.F.A.

A. Born at Berlin, September 8th 1896.

B. 1920 Study of technical physics and mathematics at the Technische Hochschule (Technical High-School) of Berlin.

1925 Degree of "Diplom-Ingenieur".

1934 Degree of Dr.-Ing. (doctor of technical science). Under the examination of Geh.Reg.Rat Prof. Dr. Dr.-Ing. H.C. Cranz and General Prof. Dr. Dr.-Ing. H.C. K. Becker (see Publication Nr.IE3).

1943 Appointed to "Ordentlicher Professor im Reichsdienst" (Professor in ordinary).

Other Appointments:

1937 Beirat des Reichsverbandes Deutscher Mathematischer Gesellschaften und Vereine (Advisory deputy of the "Reichsunion of German Mathematical Societies).

1942 Member of the Deutsche Akademie der Luftfahrtforschung (German Academy of aviations research).

CD.1)1924/1925: Siemens u. Halske A.G., Berlin.

Scientist at the central laboratory for long range telegraphy und telephony, electronice, middle and high frequencies.

2)1925/1929: Technische Hochschule at Berlin.
Allgemeine Elektrizitatsgesellschaft, Berlin (General Electric Company).

Chief-Assistant of C. Cranz at the Institute for Technical Physics and Ballistics; I had always to give the lectures and classes acting regularly for C. Cranz. At the same time I was advisory physicist of the AEG for scientific researches on Diesel-engines and steam-turbines (see Publication Nr.IE2).

3)1930/1942: Friedrich Krupp A.G., Essen.

Chief Engineer. Head of the department for scientific researches and measurements on artillery and of ship-artillery.

APPENDIX B

Dr.-Ing. Paul Hackemann
Braunschweig
Sulzbacher Strabe 26

Birth-place: Bocholt in Westfalen.

Birthday: 1st May 1906.

1925 Study at Technical High-School Aachen (College).

1930 Examination as Diplom-Ingenieur (engineering, thermodynamic, steam-power-stations).

1936 Training as civil pilot.

1941 Doktor-Ingenieur.

1942 Member of Deutsche Akademie der Luftfahrtforschung.

1930/31 Private-assistant at Prof. Dr. Bonin, Aachen laboratory for technical science of firing.

1931/33 Scientifical assistant at laboratory for engineering, Technical High-School, Aachen.

1933/35 Scientist in the ballistic department of Rheinmetall, Dusseldorf.

1935 Head of a department at Deutsche Versuchsanstalt fur Luftfahrt, Berlin, afterwards at Luftfahrtforschungsanstalt, Braunschweig.

1938 After the death of the first leader of the institute, I was charged with the temporary direction of the institute (up to 1943).

APPENDIX C

Statement of professional data of Dr.-Ing. J. Schugt

A. Personal Data

Dr.-Ing. Josef Schugt, Braunschweig, Saarstrabe 4, born at Munchen on 18 Sept. 1907.

B. Education and gradation

Bonn o.Rh.	1913-7	Common School
Bonn	1917-26	Oberreal, mature examin.
Munchen	1926-27	Techn. High School, mech. engin.
Aached	1927-32	Techn. High School, mech. engin. Diplome-examin.
Braunschweig	1944	Techn. High School, Doctor-Engin.-examination.

C. Engagements

1. Dusseldorf	1932	Economy Engineering Bureau, Assistant.
2. Dusseldorf	1932-5	Rheinmetall-Borsig, Ballistic Designing Bureau Assistant and later on Sect. Chief.
3. Berlin	1935-7	Deutsche Versuchsanstalt fur Luftfahrt (DVL) Adlershot, Aircraft-Armament Researching Institute, Chief of the Aircraft-Sight Section, employment continued in:
4. Braunschweig	1937-45	Luftfahrtforschungsanstalt.