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GERMAN AIRBORNE GUN AND R.P. SIGHTS

BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

GERMAN AIRBORNE GUN AND R.P. SIGHTS

Reported by

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
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C.I.O.S. TRIP 746A

GERMAN AIRBORNE GUN & R.P. SIGHTS.

MATERIALS COLLECTED :-

ELFE Servo System - at R.A.E.
E.Z.42 Improved Sight Head at R.A.E.
Drgs. of Steinheil Stabilised sight head - in transit to U.K.

German Airborne Gun & Rocket Sights

1. Introduction

This report is based on interrogation of German personnel shown in Appendix B during period July 17th - August 21st, 1945, on CIOS trip 746a. It is intended to indicate trends of German development rather than details of items. Some of the information given by T.L.R. has not yet been checked against contractors and may therefore be inaccurate.

2. Organisation

2.1 German aircraft sight development was administered by the E.6 branch of the T.L.R. in the OKL in Berlin, see Appendix A. These correspond to DD.Arm.DG. in CRD in the German Air Ministry. E.6 used Rechlin and Tarnevitz Research Establishments and Proofing Grounds for technical control and air trials. Rechlin was used for bombing, Tarnevitz for gunnery and rockets. E.6 in Berlin had representatives at Rechlin and Tarnevitz, also called E.6, who supervised the technical side of the sighting work, co-operated with firms, and were responsible for carrying out all trials. E.6 in TLR was mainly responsible for translating Air Staff requirements into technical terms for the benefit of E.6 Rechlin and Tarnevitz, and for initiating new projects. Once initiated, all detailed control was centred in the E.6 personnel in Rechlin and Tarnevitz.

2.2 The main firms used for gun and R.P. sighting development were Zeiss, Askania and Leitz. Later Steinheil were built up by TLR to produce Lotfe bomb sights to Zeiss designs and to carry out independent development work. Other smaller firms were used to manufacture sights to main contractors designs.

2.3 In addition to the above the Germans set up the research organisation called the Forschungs Fuehrung des OKL under Professor Georgii, see Appendix A, to control basic research work in certain Universities, Government Research Establishments and firms. This committee allotted certain gun and rocket sighting problems to LFA Brunswick (Armament Head Professor Dr. Rossman, see Appendix A).

2.4 The radar organisation was rather similar to this but had far more ramifications. The armament application of airborne radar was controlled by E.4 in TLR using Werneuchen for technical control and proofing of air borne radar, see Appendix A. The Forschung Fuehrung Committee controlled basic research but the BHF under Dr. Esau, an independent three services body set up by Goering, also had a say on a rather

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lower level than the Forschung Fuehrung. The main radar development for airborne equipment was done at FFO and ZVH Ulm, using the firms Telefunken and Siemens for development. The picture was extremely complicated and this paper is not concerned with the overall radar organisation except insofar as it is concerned with radar armament.

2.5 In addition to the above the Speer Ministry scheme was set up to co-ordinate all development and production of warlike equipment to ensure maximum efficiency in use of man power, equipment and materials. It controlled research and development through various committees, the chairman being selected from industry and the membership including representatives from TLR, Air Staff, research establishments and firms. This scheme did not affect the Air Ministry till the end of the war and had little effect on the development of airborne sighting equipment.

2.6 The main difference between this system and our own appears to have been :-

(i) The greater distinction drawn between service technical and operational personnel.

(ii) The greater concentration of control of development in the combined research establishments and proofing grounds.

(iii) The greater concentration of technical design in the selected firms.

(iv) The absence of independent proofing grounds.

(v) The absence of operational pilots from the picture.

2.7 Regarding point (i) the personnel in TLR and Tarnevitz were all Engineers commissioned or civilian rather than GD officers. A wide distinction was drawn between the engineer personnel and the operational pilots, each side looking down on the other one. Air Staff was composed primarily of operational pilots with little technical experience. The engineers had continuous difficulty in persuading the operational people to adopt the more complicated Sights and Radar Aids. The aircraft firms were also unimpressed by armament requirements. This was particularly so in the case of jet fighters which the armament people believed to have been introduced before they had been developed far enough to produce accurate platforms from which to fire the guns.

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2.8 Regarding point (ii) the headquarters in Berlin laid on the project and decided which firms should be used. Thereafter the research establishments dictated all technical details as far as the firms would permit, specified performance characteristics, tested the sight and co-operated with manufacturers.

2.9 As regards point (iii) the contractors were noticeably far less tractable and more political even than certain British counterparts. They placed representatives in the Air Ministry who saw to it that their concerns got the orders. They were in continuous competition with each other. When asked to co-operate to produce the best gyro gun sight Zeiss and Askania refused. Zeiss deliberately withheld information from the Air Ministry and Tarnevitz for fear that Askania would get to hear of it. TLR did not possess sufficient authority or knowledge to dictate technical details to the firms. The firms were of course given considerable facilities to conduct their own flight trials including supply of Service aircraft etc.

2.10 Regarding point (v) Tarnevitz had no operational pilots attached. All the flying was done by the engineers themselves. Occasionally pilots visited the place when comments on special aspects were required, but Tarnevitz complained that they were generally incapable of objective thought. This led to delays in getting their ideas across. Although TLR placed development contracts for gyro sights before the start of the war, the Air Staff requirement remained extremely lukewarm until the GGS was captured in a Thunderbolt, when high level opinion veered round sharply. Many of the civilians and service engineers in Tarnevitz were qualified pilots. Many of the projects were initiated as a result of the experiences of these engineer pilots.

2.11 The above description is based on statements made by people directly concerned with development. Little opportunity occurred for discussion of these views with the German Air Staff and operational personnel. Nevertheless it is apparent that the German administration machine creaked as it worked, and suffered from a general lack of integration by a firm and dispassionate hand at the top. Men in TLR who had dealings direct with Goering said that he possessed terrific energy but little balance. There is no doubt about the technical ability of the engineers themselves even if they were hampered by some jealousy and prejudice.

3. Weapons available.

It is necessary to consider the general trend of weapon design before discussing the sights employed.

3.1 Guns.

3.1.1. The trend of development appeared to be an urge to use higher rates of fire the larger calibre guns, increasing rate of fire at expense of muzzle velocity. Calibres up to 30 mm. were used for air to air and up to 88 mm. for anti-tank work although the latter was not successful.

3.1.2. Later trends under control of Speer Ministry stabilised on about 50 mm. calibres for maximum size with rate of fire of the order of 300 RPM. Ammunition for these was intended to make use of the HE blast effect with a proximity fuze when developed. A large number of different guns were produced during the war, of all calibres, which are described elsewhere. It is surprising that more energy was not devoted to methods of sighting them.

3.1.3. One trend of German development, dictated of course by Allied air superiority, shortage of German aircraft and particularly fuel, was to develop a special purpose multi-barrel single shot weapon of large calibre, released automatically. See Appendix C.

3.2 Rockets.

3.2.1. TLR at the start of the war did not believe that rockets were reliable enough to supersede guns for air to air work. To meet the American formation daylight raids they hastily adapted the spin stabilised ground rocket WGR.42 using the Revi C 12F sight to estimate range. This project was not very successful and was dropped.

3.2.2. They were about to introduce the fin stabilised R4M 5.5 cm. rocket fitted with an impact fuze for anti-bomber work towards the end of the war. Following their usual practice they fitted as many as possible, i.e. 24 to the Me.262, intending to fire them automatically in one rapid ripple lasting about $\frac{1}{2}$ second at ranges of about 600 yards.

3.2.3. They had also nearly completed the development of the R.100 BS, 25 cm. rocket for longer range air to air work, intending to use a pre-set time fuze and shooting in Oberon procedure (see below). Rheinmetall had a number of variations on this rocket under consideration including methods of compensating for gravity drop, use of PE and radio proximity fuzes etc. TLR proposed to fit six of these weapons to the Me.410.

3.2.4. Another rocket under development was the RZ65, a 75 mm. drum fed, tube launched spin stabilized rocket. The projectiles weighing about 2.5 Kg were fitted with time and impact fuzes.

3.2.5. All the above rockets were primarily designed for air to air. For air to ship work various unorthodox proposals were being developed including the Kurt, "bouncing ball" type of projectile. These were not considered on high priority apart from possibly the Kurt about which TLR appeared to know little, because of the war situation and also the difficulty in ranging.

3.3 Guided Missiles.

3.3.1. To complete the picture it is necessary to refer briefly to these weapons. The Germans were developing a number of different airborne guided missiles which were finally cut down to the following :-

Type	Explosive Weight	All up Weight	Control	Use
X4	20 Kg.	70 Kg.	Wire	Air to Air
HS293	40 Kg.	110 Kg.	Radio	Air to Air
FX	290 Kg.	1400 Kg.	Radio	Air to Ship
HS293	310 Kg.	1000 Kg.	Radio	Air to Ship

3.3.2. These were intended to be developed in the following stages :-

(i) Stick controlled visual sighting by the pilot, using a proximity fuze.

/(ii)

(ii) Television Control, using the same stick control allowing the pilot freedom of manoeuvre.

(iii) Homing.

3.3.3. Kruger of E.4 Peenemunde was enthusiastic about these missiles particularly for flak work where he estimated 50% saving in steel and personnel over existing flak methods.

3.3.4. It was noticeable that Oberst Mix, the man corresponding to DD.Arm.DG was sceptical about their success. He believed that guns and later R.P's would remain for a long time the main air to air weapons. The missiles were not yet perfected and would require lavishly trained maintenance and operational crews. Other prominent personnel stated that Mix was not very technically minded. He certainly gave this impression when interrogated, but may have been acting.

4. Gun Sights.

4.1 Fixed Reflector

4.1.1. The German Air Force started the war with various simple fixed reflector sights of no particular interest which were used for shooting small numbers of low calibre guns in their fighter aircraft. The technique employed was generally to close to very short ranges before shooting. Revi

4.1.2. The improved fire power on allied aircraft produced initially a tendency to develop bigger and better guns particularly for fighters. Some attention was given to bombers, but free guns tended to be hand held in the early stages due to difficulties in installing powered mountings in German bombers. Various simple methods of estimating range with reflector sights were tried. These were of no special interest.

4.2 Own Speed Gun Sights.

4.2.1. Although the Luftwaffe operational pilots were satisfied with fixed reflector sights TLR realised long before the war the necessity for predicted shooting and developed before 1939 various own speed sights, particularly the Zeiss E2A for free gun use (later improved by Oigee into the E4A). They also designed about the same time a series of mechanically operated own speed sights called VSE-A177, VSE-B-188 etc. for various turrets in the He 177 and the Ju 188.

/4.2.2.

4.2.2. Later designs of aircraft forced them to bury pilots and gunners deep inside the airframe to reduce drag and resulted in the development of a series of periscopic sights, i.e. :-

Type	Maker	Remarks
P.V.E.6	Goertz	for powered mountings, own speed.
P.V.E.8, 8 & 11	Zeiss	for Remote Control armament in Ju.388 and He.177, own speed.
Z.F.E.1a.	Steinheil	for Rear Sighting Stations, own speed.
P.V.1b.	" "	for Fighter bombers, fixed gun sights, moving bomb sight.
R.F.2a & b	" "	rearward view in fighter, fixed graticule.

Use of the periscopic layout enabled them to combine two sighting stations from one position as in the PVE.11; advantage was also taken of the possibility of adding increased protection to the gunner, particularly in the case of the ZFE.1a which poked through slabs of armour plate.

4.2.3. These sights were all designed with wider angles of view, about 40° in most but up to 65° in experimental types of Steinheil. They consequently provided little or no eye freedom at the gunners end. Full use was made of blooming to cut down reflection and increase transmission, and general design and workmanship was extremely good. TLR's intention was to use own speed sights for free guns and the gyro gun sight EZ42 for fighters. Later the EZ42 would also be fitted for free guns.

4.3 <u>Gyro Gun Sights.</u>

4.3.1. T.L.R. started development of these on low priority in 1935. The progress is indicated below :-

/Year

Approximate details of the various designs are given in Appendix D.

4.3.2. T.L.R. decided in 1944 to put the EZ.42 Askania sight into full production before trials were completed partly because of the discovery of the British sight. Several hundreds were built and installed in Me.109, Me.262, F.W.163, 190, Do.335 and Tank 153 for use with MK.151 and MK.108 guns, R4M and R.100 B.S. rockets.

/4.3.3.

4.3.3. Operational reports as far as they went, on its use in F.W. 190 and Me.262 indicated considerable improvements of the order of 2.1 over fixed sights but no factual evidence was apparently supplied. Several kills were claimed beyond 400 yards and 15° off, which were previous normal limits for reflector sights. Pilots complained of difficulty in ranging and setting altitude control. Radar range projects were in hand to eliminate the first point.

4.3.4. Further developments of the EZ.42 and 45 were planned to produce the ideal universal gunnery bombing and rocket sight. Askania were modifying the dashpot system on the EZ.42 by eliminating all but the last set in the sight head, retained against aircraft vibration, replacing the others by D.C. damping in the eddy current Ferari motor to render the system more flexible. Both firms were designing computors for feeding in bombing angle for dive and toss bombing. The Zeiss T.S.A. 2d dive bomb sight is known in principle. Askania developments have still to be investigated.

4.3.5. General comments on the above programme are that gyro gun sights could have been introduced several years earlier than they were if the German administrative machine had worked smoother and possibly been less pre-occupied with priority programmes, such as guided missiles, most of which failed to reach production before the war ended. It is interesting to note that even by removing the gyro from the sight head they failed to produce a smaller article than the G.G.S. It is not known how far Askania investigated the dynamics of their "three dashpots in series" damping system but it would appear subject to considerable variation with altitude and temperature changes.

5. Tarnevitz Gun Sighting Trials etc.

5.1 Lead computing sights were tested at Tarnevitz as follows:-

(a) turntable deflection measurement.

(b) ground tracking tests against cine camera films of aircraft flying at constant speeds to assess deflection angle.

/(c)

(c) air tracking trials against constant speed target aircraft to assess deflection angle accuracy.

(d) air tracking trials in combat manoeuvre to measure tracking accuracy.

5.2 In (b) and (c) range was estimated from size of the target in a gun camera film and angle off from comparison of target with silhouettes of model aircraft. The correct prediction angle was then computed and compared with that achieved by the sight.

5.3 They felt that these trials were inadequate and attempted to assess prediction angle under combat conditions using synchronised cine theodolites but boggled at the complexity.

5.4 Methods outlined in 5.1 were used to compare the EZ.42 with a G.G.S. captured in a Thunderbolt in September 1944. Both sights were tested in the same F.W.190 with the same pilot, comments were :-

(a) Six Spots in the G.G.S. moving graticule were inadequate (the EZ.42 has a nearly continuous ring).

(b) The centre spot in the G.G.S. moving graticule obscured the target at long range.

(c) Prediction angle of the G.G.S. varied by 1% per degree C.

(d) The prediction angle produced by the G.G.S. was on the average 20% less accurate than that of the EZ.42.

(e) Tracking accuracy with the G.G.S. measured as the mean error of the best 50% of pictures, was 20% worse than with the EZ.42.

5.5 It is considered by RAE that their method of assessing the correct angle off by comparison of silhouettes is liable to considerable inaccuracy. In addition their knowledge of the ballistics of U.S. 50 calibre ammunition was not accuracy in their own admission. These points cast some doubt on the validity of their comment 5.4 (d).

/5.6.

5.6 A further feature of Tarnevitz work of little interest is their design of EZ.42 trainers which were extremely simple and depended entirely on the competence of the instructor. For air training they used a dual control aircraft fitted with two complete EZ.42 installations, providing ½ hours flying for each pilot.

6. Automatically Released Gun Sights.

6.1 Due to the situation of the war TLR were pressing for armament installations that would produce 100% chance of destroying the enemy at the expense of specialising the aircraft. They started two programmes at LFA Brunswick based on automatic release, one against aircraft and one against tanks.

6.2 The aircraft project was called ALG1, see paragraph 3.1.3 and consisted of fitting a battery of recoilless guns of large calibre, i.e. Jaegerfaust 5 cm. x 1.6 m. six barrel installation, canting the guns to produce a trajectory perpendicular to the bomber at estimated own and enemy speed. The idea was that the safest method to attack a bomber in daylight was from the front. In the course of this attack the fighter passed underneath and extremely close to the bomb or (50 metres). When immediately beneath the bomber advantage was taken of the large plan area presented, to trigger the battery of guns automatically, in the first instance by a PE cell and an amplifier. 20 FW 190's were fitted with Jaegerfaust installations, and were on the verge of going operational. A sample of the PE cell installation is available at LFA.

6.3 The next anti bomber project was to use Radar, and FFO were developing a 15 cm Radar set for this purpose. IR was also under consideration. Both the above were to be used at night. In this case the attack would be from behind. They were very confident of the success of this project and it is believed they carried out trials against an HE 177. The total installation weighed about 350 Kgs and did not effect the aircraft performance seriously.

6.4 The anti tank project called A.L.G.2, see paragraph 3.1.3 used 7.5 cm. guns with a 1.6 metre long barrel firing a 4.5 cm. 1.5 kg. shell with a muzzle velocity of 750 metres/second. Hollow charges and armour piercing were both tried. The theory was that to attack tanks, aircraft were compelled to fly as low as possible to avoid flak. They were extremely short of armour piercing 37 mm ammunition due to lack of

/wolfram

wolfram and had in fact reserved the few rounds left for the use of a particular pilot called Rudel, who was good at the job. With the new project they proposed to attack the top of the tank with its relatively soft armour plate and with the above guns claimed they could penetrate 6 cms at 90° incidence.

6.5 The guns were triggered in the first instance by an electrostatic device consisting of a dipole picking up the potential of the earth's field and a differentiating circuit which noted the changes in this potential. They had found by experiments with German and Russian tanks that when the weather was good this method showed a high chance of success (70%). Thunderstorms etc. seriously upset their calculations. Three HE 129's are available at LFA with this device fitted. Three more FW 190's were fitted and sent to Tarnevitz for proving. Again barrels were offset to produce vertical trajectory to the tank to minimise range errors.

6.6 Further developments of this project involve the use of Radar to detect the tank. This project was called Honep and was under development at FFO and the use of IR was also discussed. Askania were using a Permalloy cored coil and measuring changes in the earth magnetic field, and the Forschungsanstalt Graff Zeplin Stutgart were working on more elaborate devices of the same type. Honef?

6.7 In general these projects appear worth further consideration particularly the anti-tank method which might have a future. The installation must of course interfere with orthodox armament and aircraft performance in spite of German claims to the contrary, leading to specialized aircraft. The disadvantage of the single shot feature could probably be got over by a fairly simple drum feed device. The use of F.M. Radar offers possibilities at the short ranges involved. Defence against this attack may also be worth considering. The use of equal and opposite guns may be worth investigating.

7. Stabilized Gun Sights.

7.1 LFA was developing a stabilized fighter armament scheme resulting from their own observations on the difficulty of tracking modern aircraft. The first step, which was as far as they had got, was to fit a movable gun camera coupled to a sight graticule into an aircraft. Both were stabilized in space by a free gyro which could be precessed by moving a small control stick. A simple Ward Leonard servo was used. Early trials in which the pilot flew on the target with a fixed graticule and the 2nd pilot steered the stabilized

/graticule

graticule and camera onto the same target showed considerable gains in accuracy. Figures could not be checked as Americans had removed all the equipment.

7.2 The next step was still under discussion. The simplest was to replace the camera by movable guns and feed in prediction via the servos, possibly using EZ.42 components. They were very keen to try and stabilize the entire aircraft however by coupling into the auto pilot. In this scheme normal aircraft controls would be replaced by a small control stick during the attack. Forward and backward movement of the stick would produce climb or dive. Sideways motion would produce accurately banked turns at constant height. By both stabilizing and simplifying the flying they hoped to achieve extremely good tracking.

7.3 Steinheil and Leitz were both co-operating on sight head design. Steinheil were developing the Z.F.S.1a periscopic head based on the P.V.1.b. with a stabilized mirror introduced into the optics. The Leitz project could not be explored as permission could not be obtained to question the personnel.

7.4 It was noticeable in this project that the existing stabilization equipment was designed to cope with oscillations of up to 5° at a 3 second period. This was the natural frequency of the Me 262 as supplied by DVL Berlin. There was no attempt to stabilize against bumps.

7.5 The only commence that can be made is that the Germans were ahead of us in this work and it is suggested that the experiments are well worth continuing. It is recommended that Dr. Hackeman of L.F.A. should be put to work on these again under suitable control.

8. Rocket Sights

8.1 Air to air.

8.1.1. The first rocket sight was the Revi C12F, a fixed reflector sight head with a 45° mirror using the span of the aircraft as the base to measure range. This was used with the WGR42 rocket. TLR had tried to develop the wide angle telescopic ZFR3 and 4 sights for the same purpose, but these were rejected by the Luftwaffe as they could not track accurately enough with them.

8.1.2. For the next rockets, i.e. R4M, R100BS, RZ65 etc. they intended to use the EZ42 predictor gun sight. For shooting

/R4M

R4M rockets air to air they found that at 600 yards the rocket ballistics were sufficiently similar to the gun ballistics to use the same moving graticule conditions. 24 rockets (on the ME.262) were to be fired in a rapid ripple lasting about half a second; the ripple was controlled automatically by each rocket as it left firing off the next one. The shooting range was measured by crossing the guns over at 600 yards and observing the point of cross-over on tracer. Later radar range was to be measured automatically by Faun (EZ42 plus Elfe plus Neptune) and fed into the EZ.42 graticule.

8.1.3. For shooting the R100BS which was intended for longer ranges than the R4M they developed the Oberon procedure which, however, never went into operation. The principle involved using a fixed time fuze type 9A of considerable accuracy (± 1/100 sec.). An automatic range strobing box called Elfe attached to the main radar was made to give two pulses at 1800 and 1500 metres. These pulses were fed into a computor called Oberon Uhr. The first pulse started a hand driven at constant speed by an A.C. motor. The second pulse reversed the hand. On its way back it wiped a moveable contact and released the rocket. The movable contact position was determined by the fuze setting in the rocket. The Oberon Uhr thus took into consideration closing speed of the two aircraft and released the rockets at the correct range to ensure a time of flight corresponding to fuze setting.

8.1.4. The prediction angle was taken care of by the EZ.42. A special time of flight setting was required corresponding to the fuze setting. One knob on the Oberon Uhr therefore was made to control at once the fuze setting in the rocket, the position of the moving arm in the Oberon Uhr and the time of flight coil for the EZ.42. A change over switch was fitted to the EZ.42 to cut out gunnery time of flight and accept the Oberon value.

8.1.5. Initially all presets including the range at which Elfe fed its pulses were ground set. Later remote controls were to be introduced for air setting. It was felt however that the whole principle was too complicated and they hoped to fit proximity fuzes to the rocket. This would enable them to dispense with Oberon and merely use Faun, i.e. continuous automatic radar range to the EZ.42 with no complicated presets and a free choice of shooting range for the pilot.

/8.1.6.

8.1.6. They intended ultimately to correct for yaw and angle of attack in both the above rocket sighting schemes. D.V.L. had done some theoretical experiments on yaw measurement and as a result Zeiss were developing a yaw motor based on a twin pitot head mounted on the wing tip on a telescopic tube. DRGS of this have already been requested from Zeiss. Askania were also developing an instrument described as based on the "variometer" rate of climb instrument. Zeiss had also done experiments on an angle of attack measuring device based on parts used in the B.Z.A. bomb sight. This scheme used an accelerometer fixed in aircraft vertical plane and an A.S.I. and computed angle of attack for mean loading conditions. T.L.R. said it was not accurate enough yet. In both projects the correction was to be applied direct on to the moving graticule of the sight hand.

8.2 Air to ground or sea.

8.2.1. Comparatively little work was devoted to these projects due to the necessity for concentrating on air defence and difficulty in measuring range. Zeiss were developing the E.M.S. 1 and 2 which measured height on a barometric altimeter, and dive angle by gyro, and computed range from these variables. A computor fed with this and airspeed drove the moving graticule of the EZ.45 sight head to the correct position for a continuous solution. The accuracy of this sight is not known. One interesting feature is perhaps the display of dive angle to the pilot in the sight itself as a possible aid to flying particularly under restricted release conditions.

8.2.2. In addition T.L.R. started trials with radar (Elfe) against shipping mainly for torpedo work without much success except in horizontal flight. Radar range to ground was barely in the research stage.

8.3 In general it was concluded that the Germans were behind RAE in development of rocket sighting against ground or sea targets. They were about parallel in their work on measurement of yaw and angle of attack and further information on these projects should be sought.

9. Guided Missile Sights

The sighting of guided missiles was generally very simple, a fixed reflector sight only being used at the moment of release, and thereafter relying on the pilot's vision to maintain the target and the rocket in alignment. For the television heads to be used with these missiles

/later,

later, the pilot merely had to keep the image of the target as shown by the projectiles in the centre of a fixed cross. Air to air blind sighting was not worked out in any detail. Various schemes were developed for Flak missile sighting however, based on Mannheim Riese.

10. Radar Armament Development.

10.1 A. Radar Range

10.1.1. About 1940 TLR and various other authorities became interested in the possibilities of using Radar range for aircraft sighting. FFO accordingly designed the Elfe equipment, 200 sets being ultimately built by Siemens of Berlin towards the end of the war. This equipment was designed as an attachment to a parent radar set, e.g. FuG.217 or 218, working on 1.6 metres. There is little novel in this equipment, the principle being very similar to that adopted in British and American equipment. The Strobe required setting on to the target range manually, after which a button was pressed and it remained locked on, through a series of relays and a motor driving a potentiometer. In later models the output was in the form of a shaft rotating lineally with the range, supplying continuous automatic range suitable for feeding into the EZ42 sight. The range was indicated between 4 kilometres into about 300 metres, with an accuracy of about plus or minus 10 metres according to the claims of FFO. The main application was initially for air to air rocket work as in the Oberon procedure where two spot ranges were fed to the Oberon Uhr. Attempts were made to use it for anti ship work with rockets and with bombs, and experiments to this end were in hand at Gottenhaven, towards the end of the war. The FuG.217 aerials were not found suitable due to the shape of polar diagram produced, except in horizontal flight.

10.1.2. Meanwhile FFO were working on a project of their own called Besenstiel. This was to be a 10/15 centimetre wave length, self-contained, continuous-automatic range only set suitable for use in single seater fighters with EZ.42. It was designed to weigh about 20 kilograms all up. Polyrod aerials giving a beam width of 25° were planned on the assumption that the maximum prediction angle of EZ.42 was about 12°. This equipment was designed to be as simple as possible to operate. It would not be necessary for the operator to set the strobe manually on to the target but the equipment would lock on to the nearest target automatically. Additional controls were being discussed to run the strobe in or out or to set it automatically to desired range. Such parts of this as were built have been removed to America.

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10.1.3. T.L.R. had also encouraged a new project on Telefunken called Eule for single seater fighters in which two Horn aerials were to be used one on each wing, as a separate transmitter and receiver using 2 cm. radar. Initially the equipment was designed to supply continuous automatic range to the EZ.42 using a 10° beam. Later it was also to supply search information mainly for daylight fighting in clouds. An alternative form appears to use a 2° beam produced by Polyrod aerials coupled by servos to the EZ.42 graticule so that they crossed at the range indicated by the radar and the prediction angle indicated by the EZ.42. This project was apparently planned for use against air, ship and ground targets for daylight use. Telefunken have yet to be interrogated on further details but it is understood that the project is some way off. TLR accordingly encouraged FFO to develop the Besenstiel project as an intermediate solution.

10.2 Radar Triggering Projects.

10.2.1. FFO were asked to work with LFA Brunswick on automatic triggering projects against aircraft or tanks to design radar methods suitable for night use. They accordingly developed the Honep technique using 15 cm. radar initially for anti tank work. They compared the return pulse from the ground with the increased return from a metal object such as a tank, and used the sudden increase in amplitude to trigger the recoilless guns. Trouble was experienced with variable returns from the ground, particularly from bowl shaped depressions and development was not complete. As in all these projects the pilot had to depress a button before the radar would actually trigger the guns. The circuits used were comparatively simple. They could not detect tanks inside woods, etc.

10.2.2. The same principle has also been developed for attacking bombers in which case the problem was simplified and any return at all was made to trigger the guns.

10.3 Blind Firing.

10.3.1. By this is meant the use of Radar to find both range and angular position of the target accurately enough for shooting. Developments were stated about 1940. TLR soon decided that until they saw their way to achieving reliable identification it was not worth putting the work on top priority, so progress was slow and confused. The name "Paukel" was given to all such projects with suffixes indicating the "parent" AI set. They were all forward-looking as the Germans had no time to waste on bomber defence after the early stages of the war.

/10.3.2.

10.3.2. The course of development can be broadly split into aerial systems and presentations. Dealing with the first, they started with lobe switching of fixed dipoles on about 1.6 metres (FuG.217). Polar diagrams were too uncertain to define the target position by percentage modulation. They therefore swung the cross-over point of the polar diagrams on to the target by varying the power of each aerial through an attenuator driven by Elfe type servos. By this means they could define target angles up to 10° off with an accuracy of about ½°.

10.3.3. The next stage in aerials was the use of parobolic reflectors on about 10 cm. (FuG.240 = Berlin NIA). Again they could not use percentage modulation, so pointed the scanner directly on the target. Since auto-lock technique in airborne equipment was beyond them they servoed the scanner off an observer-operated position control steering stick using a Magslip link. The observer steered by watching range azimuth and range elevation scopes. This equipment was introduced into Service during the last months of the war. No evidence has come to light as to performance.

10.3.4. The next stage contemplated was the use of 3 cm. Radar (Bremen) with a manually controlled paraboloid as in Berlin but using rate-control handles. Prediction angle was then to be taken either from Rádar range and rate or from the EZ.42.

10.3.5. One school of thought at FFO believed that accurate angular information would never be obtained using the cross-over point of a polar diagram due to the inevitable jitter and wander. They were therefore working on schemes for television scanning using wave lengths of .5 cm. with beams of ½°. This was in the research stage and the equipment was far too heavy for airborne use.

10.3.6. As regards the presentation to the pilot, FuG.217 and Berlin schemes merely consisted of four lights indicating "Up", "Down", "Right", "Left" and cannot have been very accurate. One of these is available for inspection in a Junkers 88 now at Brize Norton.

10.3.7. The next stage to be introduced with Berlin and later with Bremen was to supply the pilot with an azimuth-elevation presentation with range indicated by wing span or the diameter of a circle. This was to be reflected into the EZ.42 gunsight by 45° mirrors. In this scheme the

/pilot

pilot was required to range manually on to the presentation. In another scheme prediction was to be calculated from Radar range and the angular rates of the scanner and was to be fed into servos linking the scanner with movable guns in such a way that the guns always pointed in a direction to hit a target defined by the scanner. In this case the pilot flew on a fixed graticule combined with an azimuth elevation display. All this work was a long way off. Further interrogation of Telefunken may produce more information.

10.3.8. The Germans had a tendency to use Polyrod aerials in places where we use paraboloid dishes, which results in much neater installations. Use of them for radar range projects at least might be worth considering.

10.3.9. It was noticeable that the Germans paid great attention in all these schemes to anti-jamming devices. These included Taunus, in which the normal presentation was differentiated, use of Doppler effect, and the use of stroboscopic discs. Using all three at once, they attempted to overcome our jamming and our "Window". It will presumably be very necessary for us to pay attention to jamming in the next war.

10.3.10. While the later ideas are interesting, very little work appears to have been done on any of them, and it is evident that we were a long way ahead of the Germans on Radar armament. The operational personnel were not apparently very interested in any of the schemes, as they appeared to be satisfied with simple search equipment, such as FuG 217 of H2S homing gear, such as Naxos and relied on visual sighting, with Schraegermusik guns for the final attack delivered at close range. If they lost one target they said they could always find another one in the main bomber stream.

10.4 The use of radar and I.R. was contemplated for steering guided missiles at night on to the target. For Schmetterling Schoretterling Flak rockets beacons would be fitted to the missile and it would be steered by super-imposing the missile return on to the target return on a C.R.T. This method was being worked out in detail using Mannheim Reise for a scheme called "Kogge" and would later be applied to air to air work.

11. Recognisition

11.1 The Germans were as baffled by this problem as we were, but believe the television method offers some hopes.

11.2 They were working on the reflections returned from jet aircraft and found that they could receive pictures of the hot gases issuing from the rear. There is also some vague story that the hot gasses had been found to radiate automatically on radar wave lengths but information is extremely vague. They believed, however, that they could differentiate between jet and orthodox aircraft using propeller modulation effects.

12. <u>I.R.</u>

12.1 The Germans had, of course, produced equipment supplying extremely accurate angle information designed by Elac of Kiel and A.E.G. using a lead sulphide cell for detecting the radiation from engine manifolds and jet motor gases Figures of $1/20^{\circ}$ were claimed. They were thinking of using radar to measure range and I.R. to measure angle for various ground applications. They had developed a night fighter search set called Kiel but did not use it extensively because of loss of range in cloud. They also used "Spanner" similar to our type 'F' telescope in an unsuccessful attempt to home on to our type Z transmitter.

12.2 They were also devoting considerable energy to exploring the transmission of I.R. radiations through the air and incidentally through the sea and had detected the existence or various windows at $3\,\mu$ T.L.R. were encouraging research into the wave lengths between I.R. and radar in the hopes that further windows would be detected.

12.3 The Germans were very definitely ahead of us in this work. It is believed that T.R.E. are investigating it in detail.

13. <u>Conclusions</u>

13.1 From the above it is concluded that the German method of administration did not work as well as ours in that there was → more internal jealousy built into the system and more politics ← which hampered the rapid development of equipment. The sharp differentiation between Service and development personnel and the excessive power vested in industry were two main reasons for this.

13.2 As regards technical development it appears that the Germans were in general behind us, the main projects of interest being the stabilized fighter armament scheme, the automatic triggering project, the television scanning and the work on I.R. radiation, all of which seem worth following up.

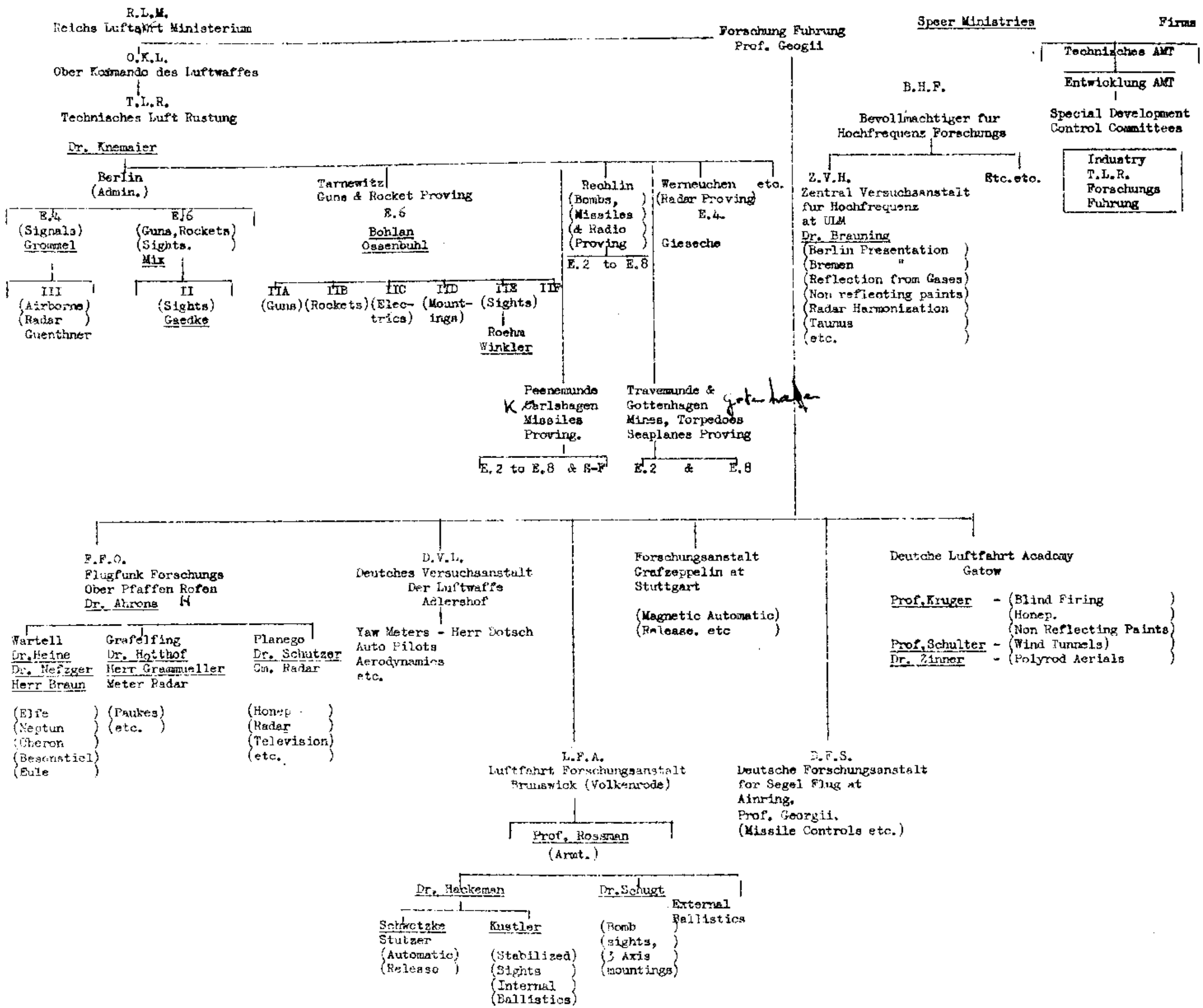
/13.3

13.3 It is also suggested that use should be made of German scientists in further research work under controlled conditions on their own lines on the projects indicated above, since it is impossible to pick up the entire background of such research by a few hours interrogation.

R.F. FISHER.

R.D.Arm.3.(b).

APPROXIMATE ORGANIZATION OF AIRBORNE SIGHTING DEVELOPMENT



SOME FIRMS ENGAGED ON AIRBORNE SIGHTING WORK

Type	Name	Place	Work on Sighting Applications	Names Underlined - Interrogated	
Instruments	Zeiss	Jena	All types of fixed and predictor gun and R.P. sights. EZ.45	Dr.KORTUM	Chief engineer on sighting.
"	Askania	Berlin	All types of fixed and predictor gun and R.P. sights. EZ.42	?	
"	Leitz	Wetzler	Fixed reflector gun sights ZFR.3 etc. Stabilized sights.	Dr.SCHAFFER	stabilized gun sights.
"	Steinheil	Munich	Periscopic sights, stabilized sights. Manufacture of EZ.42 etc. for Zeiss.	Dr.WERRNICKE Hr.MESSWERT Hr.BRAUSS	Late of Askania Bombsights, computors Stabilized gun sights
"	Goertz	Vienna	Periscopic sights, Oberon UHR mountings.	Dr.CATASTA Mr.TISCH BERGER.	Gen. development mountings.
Radar	Telefunken	Berlin	Airborne radar, Lichtenstein, Berlin, Bremen, Pauke, Eule.	Mr.MUTH, STIER, VESPER, BUHL, ZIGANKE, STEIMEL, METTEL. Various aspects of development.	
"	Siemens	Berlin	Neptun, Elfe, computors generally etc.	* Von WITZLEBEN, ROEHR, HAGENHAUS, mainly Neptun and Elfe.	
"	Lorenz	"	A.S.V. Types	Dr. CHRIST	
"	Blaupunkt	"	Naxos, Proximity fuzes, missile control etc.	Dr. GUELLNER	

Type	Name	Place	Work on Sighting Applications	Names Underlined - Interrogated
Mechanical	A.E.G.	Berlin	Servos, Gyros, Computors etc. missiles, I.R. mod.	Dr.HILGERS. Servod and missiles.
"	Luftfahrt-gerate	"	Gyros, Computors.	?
"	Deutsche Telefon Werke	"	Computors for L.F.A.	?
"	D.W.M.	Berlin etc.	General assembly and installation of gun mounting etc.	?
I.R.	Elac.	Kiel	Apparatus Kiel, Spanner etc.	Dr. KUTSCHER

APPENDIX 'B'

USEFUL PEOPLE INTERROGATED

Name	Position	Place Interrogated	Date	Remarks
OBERSTING MIX	Head of E.6/T.L.R.	Gottorf Camp, Kiel	23 - 29 July	Held in camp.
OBERSTABSING GROMMEL	Head of E.4/T.L.R.	"	"	Now in U.K.
STABSING GAEDKE	Head of E.6/III/T.L.R.	"	"	Now in U.K.
STABSING ROEHM	Head of E.6/II/Tarnevitz	"	"	Now in U.K.
STABSING WINKLER	Deputy to Roehm	"	"	Now in U.K.
OBERSTABING GIESECHE	Head of E.4/Werneuchen	"	"	Now in U.K.
Prof. ROSSMANN	Head of Armament at LFA	LFA	31 July-5 Aug	Held at L.F.A.
Dr. JACKEMAN	Section Leader under Rossmann	"	"	"
Dr. SCHWETZKE	Under Hackeman	"	"	"
Dr. KUSTLER	" "	"	"	"
Dr. SCHUGT	Section leader under Rossmann.	"	"	"
Dr. HEINE	Head of FFO, Warteweil	Seepromenade Herssing S.W. of Munich	9 - 16 Aug	Left FFO starting a firm in Herssing Ammersee.
Hr. THAETER	Under Heine on Elfe	Bauer Electricians Shop, Herssing.	"	Left FFO working in shop

Name	Position	Place Interrogated	Date	Remarks
Dr. SCHUTZER	Assistant head FFO Planege	34 Rudolph Strasse Locham, S.W. of Munich.	9 - 16 Aug	Leaving FFO
Hr. KOTTHOF	Assistant head FFO, Grafelfing.	11A Irminfreid Strasse Passing S.W. Munich.	"	Left FFO
Hr. GRAMMUELER	Under Kotthof	FFO Grafelfing	"	Leaving FFO
Dr. WERNICKE	EZ.42 work at Steinheil	Steinheil, St. Martin Strasse, Munich.	16 - 21 Aug	Still at Steinheil.
Dr. MESSWERT	Development eng. Steinheil	"	"	"
Hr. BRAUSS	"	1 Heigel Strasse, Harlaching, Munich	"	Left Steinheil

APPENDIX 'C'

AUTOMATIC RELEASE GUNS

according to L.F.A.

Use	Gun	Installation Code Name	Firm	Calibre	M.V.	Remarks
Anti Bomber or A.L.G.1.	S.G.116		L.F.A.	30 m.m.	80 m/sec.	Used MK.103 barrel. 7 barrels per a/c.
"	Rohrbloch	Zellendusch	Rheinmetall	30 m.m.	350 m/sec.	Used MK.108 barrel. 7 barrels per a/c
"	S.G.500	Jagerfaust	Hasag	50 m.m.	350 m/sec.	Preferred to others by L.F.A. 7 barrels per a/c.
"	Schlitter	-	Herman Goering Reichswerk, Brunswick.	20 m.m.	150 m/sec.	40 - 60 barrels per a/c.
Anti tank or A.L.G.2.	S.G. 113	-	Rheinmetall	75 m.m.	700 m/sec.	Used 45 min. calibre shell with expanding diaphregm.

NOTE : All barrels were cut to about 1.6 metres long.

APPENDIX 'D'

APPROXIMATE DETAILS OF GYRO GUN SIGHT DEVELOPMENTS

Type	Firm	Layout	Gyro	Control System	Remarks
E.Z.40	ASKANIA	Combined gyro and sight head.	Single AC	On-off relay.	Rejected for size.
E.Z.42	ASKANIA	Separate gyro assembly, amplifier and sight head.	2 onto pilot AC gyros.	Share potentiometer follow up system single stage amplifier magnetic clutches air dashpot damping.	Accepted for main production.
E.Z.40	ZEISS	Combined gyro and sight head.	Single AC	Field coils inducing eddy currents in copper disc coupled to motor and gyro shaft.	Rejected for instability.
E.Z.41	ZEISS	Separate gyro and sight head.	Single DC gyro	"Fly Log" polarised relays in series with main relays and slave potentiometer.	Rejected for relay trouble size for gyro and instability.
E.Z.44	ZEISS	Separate gyro and sight head.	Single AC gyro	Similar to Lofte bomb sight.	Rejected for difficulty in manufacture compared with E.Z.42.
E.Z.45	ZEISS	Separate gyro and sight head.	Single DC gyro	Free gyro on turn table which rotates till control coils possess gyro equal and opposite rate of turn.	Under development for conversion fighter bomber sight. Revi F.S. head displayed dive angle and artificial horizon.

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