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Abstract DOCUMENT CONTAINS REPORT COVERING GERMAN GUIDED MISSILE PROGRAM DIRECTED BY WERNHER VON BRAUN (UNDER SUPERVISION OF ALBERT SPEER'S MINISTRY FOR ARMAMENT AND WAR PRODUCTION) AT PEENEMUNDE, GERMANY. TOPICS INCLUDE: ME-293 AIRCRAFT, V-1 "BUZZ BOMB" (GERMAN DESIGNATION FZG-76), V-2 ROCKET (GERMAN DESIGNATION A-4), X-4 AND X-7 AIR TO AIR MISSILES, HS-293 WIRE CONTROLLED MISSILE, WASSERFALL ANTIAIRCRAFT GUIDED ROCKET (FLAK ROCKET), RHEINTOCHTER ANTIAIRCRAFT ROCKET, ENZIAN ANTIAIRCRAFT ROCKET, FEUERLILIE GLIDE BOMB, NATTER ROCKET/PROPELLED INTERCEPTOR AIRCRAFT, HOMING DEVICES FOR TARGET SEEKING (INFRARED, ACOUSTIC, HOMING DEVICES), AND MISSILE ACTIVITIES OF AERONAUTICAL RESEARCH INSTITUTION. DOCUMENT ALSO INCLUDES MINUTES OF SPECIAL COMMITTEE ON ELECTRICAL COMPONENTS OF MUNITIONS (WITHIN SPEER MINISTRY) HELD ON 13 SEP 44 AND BIBLIOGRAPHY OF GERMAN SCIENTIFIC REPORTS ON MISSILES.

Descriptive Notes: ACTUAL INCLUSIVE DATES SEP 39 TO MAY 45.

Title Added Entries GERMAN GUIDED MISSILE DEVELOPMENT

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Ground Guided Missile Development
Oct 1945

M.Roddenbery/jr/3797

AC-31512

4 October 1945

MEMORANDUM FOR THE COMMANDING GENERAL, ARMY AIR FORCES:

SUBJECT: German Guided Missile Development

1. There are forwarded herewith nine (9) copies of a report entitled "Historical Notes on German Guided Missile Development" prepared for the AAF Scientific Advisory Group. It is believed that this report will be of interest to agencies concerned with guided missile development.

2. It is recommended that this report be distributed to technical groups through AC/AS-2 channels and that the following agencies be included in the distribution:

AC/AS-4
ATSC, Wright Field, General Craigie
ATSC, Wright Field, Colonel Meyers
Chief of Ordnance, ASF, Colonel Ritchie
Navy, Bureau of Aeronautics
Navy, Bureau of Ordnance
Navy, OCNO
National Advisory Committee for Aeronautics, Dr. Lewis

HUGH L. DRYDEN
Acting Director
Scientific Advisory Group
Office of the Commanding General

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DOD DIR 5200.9, 27 Sep 58

AFSC 62-202C

KO-31512

Historical Notes on German Guided Missile Development
(From Interviews of various German scientists
by AAF Scientific Advisory Group)
Reported by Hugh L. Dryden, Consultant
AAF Scientific Advisory Group.

PC 1400 FX

This guided missile, the first to be used operationally by the Germans, is an aircraft-launched armor piercing bomb with rudimentary wings which can be remotely controlled by radio along a trajectory which may be made to depart from a normal bomb trajectory by amounts of the order of 700 to 1000 feet. The operator watches the bomb and target visually. The missile was used against ship targets.

According to the designer, Max Kramer, this development was started in November 1939 at the Deutsche Versuchsanstalt für Luftfahrt, Berlin-Adlershof. The firm Rheinmetall-Borsig undertook the production and Kramer joined them. A brief account of this development was presented at a special meeting of the German Academy of Aeronautics on November 5, 1942. The first operational use of the missile was in August 1943. The time required for its development was therefore 45 months.

Hs 293

This missile is an aircraft launched glide bomb, accelerated by a liquid fuel rocket for 10 to 15 seconds just after release. It is remotely controlled by radio by an operator in the releasing aircraft who watches the bomb visually. The missile was used against ship targets.

The designer was Herbert Wagner. He joined the Henschel Company at the suggestion of Dr. Lorenz of the Air Ministry and began the development of Hs 293 on February 1, 1940. The first successful tests were made at Peenemünde on December 16, 1940. The starting rocket was not used until the end of 1941. This missile was also described at the special meeting of the German Academy of Aeronautics on November 5, 1942. The first operational use was in October 1943 and hence the time required for development was 44 months.

V-1 = Fi-103

This missile is the well-known buzz-bomb, a winged long-range self-propelled missile launched either from the ground by a special catapult or from an aircraft. It is used against large ground targets.

According to A. [illegible] who was consultant to the German Air Ministry on the development contracts and Dr. Ing. Günther Diedrich of the Argus Company the history of V-1 is as follows. An inventor, Paul Schmidt, had a development contract from the Air Ministry for an intermittent jet motor in 1935. The work proceeded slowly. About November 1939 Diedrich of the

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Argus Motor Company who had been working for the Air Ministry on exhaust pipe jet propulsion nozzles began work on intermittent combustion in an open pipe. In 1940 the Air Ministry brought Schmidt to the Argus Company and combined the developments. The first successful motor was completed in 1941, not however of the size used in V-1. Just when V-1 itself was conceived and by whom is not entirely clear. Wagner stated that the Air Ministry told him in June 1942 that work on long range guided missiles should be resumed. The motor development itself was intended for use in aircraft. Busemann stated that when work on the V-2 rocket, a development of the ground forces, was delayed, Schelp, an assistant of Lorenz in the Air Ministry, proposed the use of a combination of small airplane with intermittent jet motor for the same purpose. V-1 is thus a development of the air forces. Its code name was originally Kirschkern (cherry pit) because it was merely to be spit out against England.

Presumably Schelp's suggestion was made in 1941. Fieseler Aircraft Company was selected to build the air frame. The development tests were made at the Air Ministry laboratory at the Luftforschungsanstalt Hermann Göring, Braunschweig, in the 2.6 m high speed wind tunnel. The original model of V-1 was not very good, the net thrust of the motor being zero at 360 mph. About 60 per cent of the time of this wind tunnel was used for nearly a year to bring the development to its present stage.

The first reconnaissance photograph of V-1 was taken by the British at Peenemünde in April 1943, and Peenemünde was made uninhabitable by bombing in August 1943. The first operational use was on June 12, 1944.

Busemann stated that the V designation originally meant simply Versuchsmuster (experimental type) and the interpretation as Vergeltungswaffe (vengeance weapon) was an after thought of the SS propaganda groups.

V-2 = A-4

The V-2 or long range rocket was known as A-4 or Apparat 4 (apparatus no. 4). According to Busemann A-1, the first of the series, was fired in 1935 at Kummersdorf. It was a small rocket with thrust of 100 kg of aluminum construction, intended for use on aircraft.

Dr. von Braun, leader of the Peenemünde group which developed V-2, was a student of Professor Hermann Oberth, a well known inventor and writer in the field of rockets who has published books on interplanetary rocket travel. A group of these students became interested in rockets and organized an amateur rocket group. All were well trained scientists. In 1935 Dr. von Braun was employed by the German War Department and sent to Peenemünde. In 1941 von Braun brought Oberth there as head of the Patent Section. By 1941 Peenemünde was an active test station. The Me 163 was brought there in Sept. 1941 and in October 1941 flew at a speed of 1003 km/hr. In October 1941 the first wind tunnel tests were made on a projectile at a Mach number of 4.4. After the bombing of Peenemünde in August 1943, the activities were

decentralized. The wind tunnel group went to Kochel, where it was in operation in January, 1944.

The writer does not at present have detailed information as to the intervening history of V-2. Its first use was on June 13, 1944.

Kramer's Later Missiles, X4 and X7

According to Fraser, the development of an air to air missile designated as S-4A or X4 was begun in June 1943. This missile weighs 60 kg and is 1.9 m long. It has four sharply swept back wings near the center of gravity and four tail fins. Aerodynamic control is by means of spoilers on the tail fins. Tabs on the wings cause the missile to spin. Two of the wings carry at the tips spools of fine wire 0.22 m in diameter and long enough to permit a range of 5 km while maintaining direct wire connection to the control aircraft. A gyro stabilized commutator in the missile and a suitable filter system permits direct electrical transmission of the control from the operator to the spoilers on the control surfaces of the missile by means of the connecting wires which can feed out at speeds of more than 200 m/sec.

About 100 X4 missiles were built and a document dated January 11, 1941 stated that 130 trials had been made. It was stated that the missile was in the early testing stage to prove its fundamental correctness of functioning. At one time the Air Ministry had a requirement for 5000 by the middle of 1943 but this was later reduced. In February 1943 SS leader Kammler ordered a lower priority and the closing out of the project at the end of the development period.

Kramer designed an acoustic proximity fuze for this missile known as "Kranich". About 30 were built and some preliminary fly over and fly by tests were made. The effective range was expected to be 45 feet. The tests which had been completed were promising. Work was also under way to develop an acoustic homing device with a hoped for range of 500 to 1000 meters.

X-7 was a smaller edition of X-4 for use against ground targets. Apparently it had not proceeded beyond the design stage.

Wagner's Developments of Hs 293 Type

Wagner stated that the original Hs 293 is more properly designated Hs 293A. Beginning also in 1940, a control using wires joining the missile to the mother airplane was developed to be used if the radio controlled version was successfully jammed. The wire controlled version was known as Hs 293B.

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Parallel with the Hs 293 development, Wagner designed a bomb to strike the water in front of a ship and then travel in a suitable underwater trajectory. The wing and tail system were similar to Hs 293 but were notched to break off on impact with the water. The development moved slowly, having no great priority, but was ready in the early days of 1944. There were then no airplanes available to carry it. This development was designated Hs 294. A smaller version was known as Hs 293C.

Hs 295 and Hs 296 were the same fuselage as Hs 293 with general purpose bomb and armorpiercing bomb as payload. Hs 293D used television equipment, the first tests being made in the middle of 1942. A few tests were also made in 1944, but the television equipment was never completely satisfactory.

All glide bombs were abandoned for lack of planes to carry them. In May 1941 Wagner proposed a ground to air rocket propelled missile known at various times as S-117, Hs 297, SI, and Schmetterling. A contract was not actually awarded until August 1943. Work was started however in May 1943 on this weapon and on an air to air weapon Hs 298. These developments were not completed. The starting weight of Hs 297 was 440 kg, its speed about 0.8 the speed of sound, its final weight 175 kg. These missiles were to be controlled by direct radio control. On Jan. 22, 1945 some 80 missiles had been tested, most with radio control. About half of those tested functioned properly. A scheme for control with tracking and a computer was under development. It was also planned to use some form of proximity fuze.

Some further details of Wagner's activities are given in USSTAF A-2 Technical Intelligence Reports I-2 and I-2a.

According to a P/W report series production of the Hs 117 began on a large scale in January 1945 at an underground factory at Woffleben near Nordhausen in the Harz mountains which was controlled by the Henschel company. Hs 298 was also being produced by Henschel working under the code name Oder AG in a factory in an underground railway at Berlin-Neukölln.

Further V-1 Developments

There seems to have been no concentrated and unified effort to make a better missile of the V-1 type. There are a number of records of research on methods of cheapening the construction and using substitute materials for the control gyros and servos. There is a record of a meeting of the Armament Section of the Ministry for Armament and War Production in June 1944 in which expected shortages of sheet metal and explosive for V-1 were discussed. Finally in the German Emergency Development Program there were projects to use an Argus 014 aeropulse motor and also a Porsche 005 turbojet motor in the V-1 air frame to increase its range. The Argus 014 is an aeropulse with improved altitude performance and life and the Porsche 005 is a simple and cheap turbojet of low grade materials.

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The Peenemünde establishment for testing and a number of projects on the aeropulse motor, including one airplane, as well as using the aeropulse motor for propulsion. This airplane was to be used for thrust measurements in flight at high speeds. It was stated that "these results must be obtained to be able to determine the maximum range and velocity of rocket." (File No. C-103, p. 19) The V-1 are all designations of the V-1 missile. This statement was made on March 31, 1944.

Further V-2 Developments

The later developments of A-4, the German designation of V-2, were A-5, A-6, A-7, A-8, A-9, A-10 and A-4 also called Wasserfall. With the exception of A-9 and of Wasserfall which received priority at the beginning of 1943 the other developments were restricted to design studies, wind tunnel tests and performance calculations. A-5 to A-10 were all ground to ground weapons. A-5 was a small scale A-4 used for experimental purposes. A-6 was a rocket of A-4 for a different fuel combination. The next important step was the design of A-7 which was the small scale A-4 with wings. A-8 and A-9 were designed of the same weight and form as A-4 equipped with wings, A-8 using liquid oxygen as oxidizer and A-9 using nitric acid. It was computed that the use of wings would increase the range of A-4 to 2,000-2,500 miles. In A-10 the A-9 rocket was to be launched with a booster rocket of 100 tons thrust, giving two step operation. It was computed that a range of several thousand miles could be obtained. The explosive load would be about 1 percent of the starting weight.

There is every evidence that no actual firings had been made of A-9. In a report of March 15, 1943, Dr. Hermann, aerodynamicist of the Peenemünde wind tunnel group, states in recounting the story of the development of Wasserfall that the build range of A-4 was selected for Wasserfall because of previous experience. He states further that the group had "some experience but only in the wind tunnel on a glider model which was a further development of A-4."

Wasserfall

Beginning in early 1943 (one source gives September 1942 as the starting date) the entire resources of the Peenemünde group were concentrated on the development of an antiaircraft guided rocket first designated A-4 and later Wasserfall. The first experimental firing was made on February 28, 1944. By January 1945 twenty-five experimental firings had been made all but one with radio control. Fifteen of the firings gave satisfactory flight.

The Wasserfall missile is 88 cm in diameter, 760 cm long, has a launching weight of 3570 kg, and a final weight of 2015 kg with pay load

of 345 kg of explosive. It is rocket propelled for 45 seconds with a [illegible] rocket of 8000 kg thrust. The maximum speed is about 770 meters/sec and its maximum height 10.3 km. The horizontal range is 26.5 km.

The control method was designated "Rheinland" which was to be developed in four stages. In the first stage the rocket was to be steered by direct radio control according to the eclipse procedure as used for [illegible] and Ju 88 with the aid of optical two-axis tracking apparatus. The decimeter-wave control transmitter was to be used. At night searchlight beams were to be used. So far as known at present the tests completed were made with this equipment.

The second stage used radar tracking of missile and target with a suitable visual presentation. A human operator was still used with radio transmission of the control information.

The third stage was the automatic control, the radar tracking device being coupled through a suitable computer to the control stick.

The fourth stage was beam guiding with a homing device for the final stage of the trajectory.

According to one report (unpublished and unfinished manuscript on "Systems of Beam Guiding" found at Brunswick) dated March 25, 1945 it had been determined by the Peenemunde group that the control described in the second stage above could not be carried out because of the slowness of the human brain and that therefore the control signals must be formed electrically and transmitted automatically to the missile.

The Peenemunde group developed an infra red proximity fuse for use with Wasserfall.

The history of the aerodynamic development of Wasserfall is given in a report AVA 171 by Dr. Kurzweg entitled "The Aerodynamic Development of the Flak Rocket Wasserfall." This interesting document brings out the fact that Wasserfall was in addition to its immediate application a contribution to the aerodynamic development of the long range winged rocket. More than 25 designs were tested in the supersonic wind tunnel at speeds up to 3 times the speed of sound. The lift-drag ratio was 4.15 at low speeds, 4.42 at mach number 0.8, 3.90 at mach number 0.94, 2.90 at mach number 2.30.

No data are available to the writer on the production plans for Wasserfall. On Feb. 6, 1945 the SS leader Kammler who had been given authority over the development of guided missiles stated that the Wasserfall project would be closed out at the end of the development period, priority being given to unguided rockets such as Taifun.

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Rheintochter

This missile is an antiaircraft rocket developed by Rheinmetall-Borsig, one of three similar developments sponsored by Hitler of Gr Flak 15, the others being Wasserfall and Enzian. The first experiments with steering were made in February 1944. According to one report Rheintochter was abandoned in favor of Ru 147 after a demonstration to Goering and Speer at Karlshagen in October 1944. On February 9, 1945 Dr Leader Ambler stated that Rheintochter was to be closed out at once.

Rheintochter had a diameter of 53.6 cm, a length of 500 cm, a starting weight of 1570 kg, final weight of 685 kg, with a pay load of 100 kg of explosive. Its maximum speed was 410 meters/sec, maximum height 13.2 km, range 18.9 km. It was launched with powder rockets. On January --, 1945 82 tests had been made, 39 without control, 21 with preset program of control, and 22 with radio control. 56 functioned satisfactorily.

Enzian

This is the third AA rocket sponsored by Gr Flak 15. It was designed by Dr. Wurster, chief test pilot of Messerschmitt and holder of the 1939 world's speed record in the Me 109. The development was begun in November 1943. Work was interrupted by the destruction of the Messerschmitt plant at Augsburg in February 1944. The project was moved to Bernbrofen and later to Schlossmirtschaft Lindermof near Oberammergau. A document dated January 27, 1945 said that 23 missiles had been launched, all without control, and that 11 were failures. On Feb. 24, 1945 the aerodynamics man Sabonitz wrote in an internal memorandum as follows:

"For the further work a clear leadership must be created with definition of responsibility. Now Dr. Wurster, Dr. Thiel, Dr. Imar, and Dr. Muhlberg have some authoritative influence without a plan of organization and without a leader. The previous lack of success does not lie in the technical sector but is solely a question of leadership."

"No information on aerodynamic and flight performance has been obtained from the test firings because the firings were marred by explosions, failures of launching rockets, etc."

The work was ordered stopped on January 17, 1945. Messerschmitt intervened and took the matter to Hitler himself but the work was finally stopped about the middle of March.

There were several designs of Enzian. The subsonic version was similar in design to the Me 163 airplane which has no horizontal tail surface. It was 90 cm in diameter, 305 cm long, starting weight 1000 kg, final weight 690 kg with pay load of 300 kg of explosive. Its maximum speed was about 270 meters/sec, maximum altitude 13.8 km, range 25.3 km.

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In the tests a conventional radio control was used. It was intended to use an acoustic homing device or an infra-red homing device.

A larger supersonic version with pay load of 500 kg was also designed.

Hecht, Feuerlilie

The LFA Braunschweig had a development program on a glide bomb, Hecht, and on a flak rocket, Feuerlilie, which moved very slowly. The glide bomb Hecht was developed in the period from early 1940 to late 1941. A few drops were made but nothing came of the development.

The work on Feuerlilie began in early 1942, was given high priority in early 1943, stopped late in 1943, later revived, and again stopped in early 1945. Three models of smaller size, designated F-5 were fired in May 1944 and one of the intended size F-25 was fired also in May 1944. Much theoretical work was done on the theory of homing missiles and the theory of beam-guided missiles. The actual tests made were not very satisfactory.

The LFA was finally instructed to use ration or schnaitsee for its beam guiding experiments but no such experiments were actually made.

The Feuerlilie weighed 600 kg and had a maximum speed of about 220 meters/sec. Its maximum altitude was about 6 km. It was 25 cm in diameter and 480 cm long.

This project suffered because of lack of support by an industrial group. Two statements by Steinz, Director of the LFA, which were made in 1942, illustrate the situation. Reporting on missile research in Germany in 1942, he says:

"Work is in progress on remote controlled bombs in Germany in various places in industry and in aeronautical research laboratories. In spite of the many fronted aspect of the problem it is desirable that the experience collected in these projects should come to the knowledge of all agencies active in this field more quickly and completely than hitherto. In this the communication of negative results is especially important since much time would be saved thereby."

"While industry is capable of making rapid progress in these problems because of their large workshops, the research laboratories must take up ever closer negotiations with industrial firms to have their designs constructed at least in a few samples and to test them. More time support is to be desired for the more rapid completion of such jobs."

In a report on the LFA guided missile research in 1942 Hanck states that he, Braun, Aerris, and Hebert have been working on an air-to-ground rocket-propelled remote-controlled missile since the beginning of the war

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and on a ground-to-air rocket-propelled remote-controlled missile for about one year. He says that numerous problems were encountered, for example:

1. Necessity of automatic stabilization in roll
2. Suppression of the phugoid motion
3. Influence of jet propulsion on the flight characteristics
4. Stability at extreme inclination of flight path
5. Development of suitable antennae
6. Influence of jet on radio receiver.

Natter

The Natter project, while not an armed guided missile, should be mentioned. It is a manned rocket-propelled interceptor airplane armed with 24 rockets of 7.3 cm caliber. The airplane was intended to be launched nearly vertically by means of two or four solid-propellant launching rockets toward a point about 2 km behind the point of collision so that attack on a bomber could be made from the rear. A steel plate ahead of the pilot served as armor plate and as a deflector of the ejected from the rocket projectiles. After the rocket ammunition is exhausted, the airplane is caused to disintegrate, the nose section allowed to fall freely and be ejected out the air frame with rocket propulsion motor and the pilot are saved by parachutes.

The propulsion motor is the Walter rocket motor used in the Me 163 and by using this already developed motor, the Natter project could proceed very rapidly. The project was originated by Bachem and the chief designer was Dipl Ingr, formerly chief test pilot of Messer. Actual work was started on the project in October or November of 1944, and the project was well advanced when Germany fell.

Homing Devices

At a meeting of the German Academy of Aeronautics devoted to Special Problems of Remote Control on November 5, 1941 there was one paper on homing devices for missiles by Edgar Lutzeyer entitled Infra-red equipment for Target-seeking Apparatus. Many laboratory projects on homing devices were authorized by various agencies from this time until the end of the war. The Minister for Armament and War Production, Speer, in July 1944 created a number of agencies to review research and development programs and establish priorities. One of these agencies was the Main Electrotechnical Committee which established a Special Committee on Electrical Components of Munitions under the chairmanship of Prof. Dr. Gladenbeck who had previously been associated with the Forschungsanstalt der Reichspost. A subcommittee of this Special Committee, headed by Dr. Runge, covered the field of proximity fuzes and homing devices. A survey by this subcommittee showed 25 projects for homing devices, of

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which 6 were acoustic, 9 infra red, 2 optical, and 6 radio or radar devices. The list is included as appendix 1 to this report. Three of these were infra red devices under development by Dr. Kutscher for which the developments in two instances were said to be nearly completed as of August 15, 1944.

Appendix 2 contains extracts from the minutes of the Gluecheck committee. A reading of these minutes and of various other documents leads to the conclusion that none of these devices were out of the laboratory stage and that the development of homing devices lagged considerably behind the development of vehicles and their propulsion.

Missile Activities of the Aeronautical Research Institutions

The aeronautical research institutions gave a great deal of attention to missile problems by conducting wind tunnel tests and making many theoretical investigations. The Deutsche Versuchsanstalt für Luftfahrt, Berlin, (DVL) was largely active in the development of the FX and made at least one series of measurements on the X4 and on V-1. The Aerodynamische Versuchsanstalt Göttingen (AVA) made wind tunnel measurements on Rheintochter, Hs 117, Zitterrochen, and on long range rockets. The Luftfahrtforschungsanstalt Hermann Göring, Braunschweig, (LFA) made aerodynamic measurements on glide bombs, did the major wind tunnel work on the V-1 aerodynamic motor, undertook the project research already described, and did considerable work on the theory of stability and control of missiles especially homing and beam guided missiles.

One of the key groups in the missile developments of the German air force was the Deutsche Forschungsanstalt für Segelflug. To illustrate the large part played by missiles in the program of this institution an abstract of the DFL progress report for the period Dec. 1, 1943 to March 31, 1944 is attached as appendix 3. One important contribution of this group was the development of equipment for simulating missile flights which permitted tests of different control systems and the training of pilots in remote control.

An incomplete bibliography of reports from these and other institutions on guided missiles is attached as appendix 4.

The Pressers and Promoters

Mention has already been made of Professor Hermann Oberth and the part played by this high school professor in stirring the imaginations of the young engineers who later developed V-2. His early activities in cooperating with UFA in making the motion picture Frau im Mond with its space rocket sequence and his two books the Path to Space Ship Travel and by Rocket to the Planetary Regions are perhaps sufficient to

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clarify his personality. Oberth did considerable puttering in the laboratory and made many sketches and patent drawings of very large rockets. His pupil, Dr. von Braun, took him to Peenemunde as head of the patent section. While there he studied the design of a long range rocket to travel 8000 km. He decided it could be made with present materials but that it was not practical, since 90 tons starting weight would be required for each ton of useful load, even though the step-rocket principle was used.

A man with somewhat better engineering training but of the "promotor" type is Professor E. Sänger who was at the end of the war active at the LFA in the Division of Special Propulsive Devices. From 1937 to 1944 Dr. Sänger was in charge of a large rocket research station at Trauen near Fallingbostel operated under the direction of Ackermann of the LFA at Braunschweig. Sänger had planned this station for the study of high-velocity high-temperature rockets. He had grandiose plans and wished to develop a 100 ton rocket. The engineers at the LFA found Sänger's measurements unreliable and his engineering in their opinion incompetent. Sänger left after a quarrel in 1944.

Sänger wrote another volume, to his well known book on rockets in which he discussed the problem of bombing New York City from bases in Europe. The accounts in the book are considerably in advance of actual technical accomplishments in Germany, yet not in error as to the possibilities of future development. The more conservative engineers of the Peenemunde group (such people as Dr. Hermann and of course Dr. von Braun who is a good salesman for his group and does not always present the distinctions between foreseeable scientific development and fancy) agree that sufficient information is available to permit the development of a transoceanic rocket within a period of 3 to 5 years, if such an accomplishment is deemed worthwhile.

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German Projects on Homing Devices stated to be in progress August 15, 1944

I. Acoustic

1. "Dogge" Dr. Benecke; Messerschmitt, Hollein and Telefunken, Elac
4 microphone sondes, 4 phase true amplifiers, 12 to 16 tubes, two phase meters with bolometer amplifier. Range over 350 m with Me 262 units. 40% developed.

Note. On January 25, 1945 the C series was said to be under construction. Intended for X4 missile.

2. "Luchs" Dr. Hecht; Elektroakustic, Kiel.
Phase measurement, 12 tubes, 2 phase relays, range 1.5 to 2 km, weight 15 to 20 kg. 60% developed.

3. "Pudel" Dr. Kremer. Ruhrstahl.
Directional head, amplitude differences, 4 resonance senbrsnes, 2 to 3 tubes, range 500 to 1000 m, projected for X4 missile.

4. -- Dr. Trage; Reichspost.
Phase difference, 4 microphones, projected for Rheintochter.

5. XX5 Dr. Schope; RAE Wurzburg.
No information.

6. -- Prof. Kussner; AVA Gottingen
No information.

Note. Relieve Kussner did only theoretical work on acoustic homing.

7. -- Prof. Lubke; Brunswhweig.
No information.

8. -- Dr. Heymann; Darmstadt.
No information.

II. Infra-red

9. "Hamburg T" Dr. Kutscher; Elektroacoustik, Hamalau
Mirror 25 cm diameter, 7 tubes, weighs 20 kg, range 3 km against ships, development nearly completed.

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10. "Anton 2" Dr. Kutscher; Elektroacoustik, Hamelau.
Television type scanning, proportional indication, 1200 to 1500 m against He III, 11 tubes, 45° field, development almost completed.

11. "Hamburg II" Dr. Kutscher; Elektroacoustik, Hamelau.
Wide angle objective, 7 tubes, 1100 m against large ships, 20° field, in process of development.

12. "Glühwürmchen" Obering Drenkelford; Rheinmetall, Breslau
Optical lens, spiral scanning, 8° field or 3° field, weight 3 kg, 3 samples available, production of 50 in hand for Gl Fiak 2.

13. -- Baron Pfeiffer; Kepka, Wien
Mirror 26 cm diameter, 3 tubes, range probably 3000 m, 18° field reducing to 1 1/2° on picking up target, preproduction run of 50 samples.

Note. 0 series probably under construction in January 1945.

14. "Nitshant,""Krebs." Dr. Orthuber; AEG
Lens system with scanning, on-off control, 700 m against He III, 8° field with 4.5 cm optical system, 3 tubes, photo cell, in development.

15. "Widder" Dr. Bilgers; AEG Research Lab
Two systems in development with 3 tubes and thyratron.

16. "Linse" Dr. Kober; Gema, Berlin
Minor system with Schwarzschild comparison system, 3 tubes, elect cell for control in 1 coordinate, completed. Control in 2 coordinates under development.

17. -- Dr. Henke (?); Phys. Lab. Zeppet
Same as 12 (Glühwürmchen) but combined electrical and mechanical scanning, 5 to 6 tubes, weight 3 to 4 kg, 5° field.

III. Optical

18. "Pineal" Dr. Bambauske; Ges. f. Forschung u. Entwicklung
Iconoscope, spiral scan, rectilinear coordinates, 2000 m, 20° field, 8 tubes, midget iconoscope, directing device for iconoscope, prototype available.

19. -- Dr. Himmler; DVL (JARO?)
Similar to 15 (Widder).

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IV. Electrical

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20. "Windhund" — Dr. Gross; RPF
Passive type, receiver for Wasco 2, full automatic switching, range of a few km, 25° field, stiele-strahler, probably 9 tubes, to be used against Rotterdam or Medda-birat apparatus.

21. "Radieschen" — Dr. Bruckmann; RPF
Passive type, direction finding on Poynting vector, range 80-100 km for 1 kw transmitter, 10° field for continuous control, gives on-off for 90°, Strassburg receiver with additional l.f. stage. Present weight 10-12 kg for search head, 5 kg for receiver and converter. A few W samples available for testing with FX missile.

22. "Licht" or "Moritz"? Dr. Pressler; RPF DFR
Active type, radar transmitter external to projectile, receiver only in missile. Range 1000-2000 m, 9-11 tubes, "bugs" being taken out.

23. "Blaulicht" — Dr. Beymann; RPF
Similar to "Licht" but shorter waves. Has 9 to 11 tubes, range 1000-2000 m, "bugs" being taken out.

24. "Dackel" — Dr. v. Oettingen; RPF
Active type, complete radar. Good range resolution at short ranges, 50 m, (back edge of impulse). Range estimated as 1000 m, 20° field, 12 controlled tubes, 2 dioden, weight 3 to 4 kg without battery. Laboratory sample under construction.

25. "Max"? — Dr. Güllner; Blaupunkt Werke
Active type, CW. Transmitter decoupling by Doppler effect. Range expected 500 m, 15° field, 10 tubes, magnetron. Development just began.

Notes. RPF = Forschungsanstalt der Deutschen Reichspost.

Gladenbeck Committee, Sept. 13, 1944 mentions 1, 16, 18, 20, 21, 22, 23, 24, 25 and two not identified.

Gladenbeck Committee, Nov. 8, 1944 mentions 1, 2, 9, 11, 16, 18, 22, 24 and one not identified.

Document of January 29, 1945 states that the work of the Gladenbeck Committee on target seeking devices has not yet led to a successful conclusion. In some places the impression appears to prevail that it would be preferable if the Gladenbeck Committee worked with a greater concentration.

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Extracts from Minutes
of
Special Committee on Electrical Components of Munitions
(Gladenbeck Committee)
of the
German Ministry for Armament and War Production
(Speer Ministry)
relating to development of homing devices
for guided missiles

Meeting of September 15, 1944

Prof. Dr. Gladenbeck in an introductory statement explained that the session was for the purpose of reporting on the previous work of the Special Committee on Electrical Components of Munitions. At the same time he requested the representatives of the using services to make known their present wishes as to the decisions made by the committee and already discussed with them. Prof. Gladenbeck stated further that the work of the special committee covered the three fields, proximity fuses, homing devices, and control devices (servos, etc.). The first task consisting in making a survey within the committee of the individual development projects. Finally after thorough consideration a consolidation or elimination of a great number of the developments found to be in progress will be made in order to arrive in this manner at a determination of the most important principles (Schwerpunktbildung = literally formation of the center of gravity). It is assumed that the survey of the individual developments is almost completed. For the case of proximity fuses the special representative for fuse questions in the munitions committee, Major-General Heydenreich, has carried out a similar survey and has arrived at approximately the same number of developments in progress. The limitation of developments has been carried out in such a manner that nothing essential has been lost. In the further conduct of the development, those development agencies, in general, have been supported with approximately the same number of proposals whose developments have progressed the furtherest. Greatest priority has been given to aircraft rockets. Work in this field can be carried out with special acceleration since Minister Speer has designated Prof. Gladenbeck, as his special representative for the development of a complete air to air rocket.

Prof. Gladenbeck named the chairman of the individual subcommittees, as follows:

For proximity fuses and homing devices: Dr. Runge
For stabilization and control: Dr. Bilgers
As liaison officer for electrical power supplies:
Dipl.-Ing. Böhm.

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Then Dr. Runge reported on the work of his department

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[Discussion of proximity fuze developments]

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Dr. Runge then reported on the organization of developments of homing devices which had been accomplished.

In the acoustic field there had been developed a unit device, at first for the X4 missile. A working personnel had been organized under the direction of Dr. Bomke. The development work was being done by Dr. Bomke, fundamental investigations in the Physikalische-Technische Reichsanstalt by Dr. Obermeyer at Lorenbrann. The unit homing apparatus contained four microphones, and two measurements of phase were made for the vertical and lateral errors. The available types of microphones had been measured by the P.T.R. The result was that the AVA microphone which depends on the cooling of a bolometer wire by the sound was by far the most favorable. It had the greatest sensitivity and the greatest freedom from disturbance by vibration.

In the optical field, two types were developed, one for reflection optics, the other for refractive optics. For marine purposes the development "Linse" [control in one plane] also is in progress.

Independent of these developments, Dr. Bomke is working on the development of apparatus on the principle of the iconoscope. [Use of variations in brightness produced by a target]. It is still to be clarified whether the iconoscope can be manufactured in the required quantity.

In the electrical field there are 6 developments in all, in progress, five at the Post-Office Research Laboratory and one at the company, Blaupunkt. Two passive devices [receiver only] are provided for attack on Rotterdam installations [code name Windhund] and for attack against ground targets, for example enemy radar installations [code name Radieschen]. For the two active devices "Spaniel" and "Max" only studies are in progress at the present time. In the pulse type "Spaniel" the problem of the close-up resolution is especially to be solved, while for the device "Max" which operates with continuous waves and Doppler effect, ground reflections will probably cause difficulty. The last two developments are to be designated as semi-passive, since the transmitter is outside the missile. Also for these two developments only studies are in progress at the present time.

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The following discussion results from the presentation of homing developments by Dr. Runge:

Prof. Gladenbeck - These developments are still proceeding along very broad lines since fundamental questions have not been clarified.

Oberbaurat Johannsen - In what stage is the development "Tinsel" of Dr. Rambauske?

Dr. Runge - At present it is not clear what Rambauske can offer in the way of contrast; besides there are difficulties in the manufacture of a sufficient number of iconoscopes. A further demonstration will be given by Rambauske at the end of September.

Chief Staff engineer Bree: The experiments which have been made with "Tonne" against sea targets leave no exciting expectations for ground target use since there the contrast will be still worse.

Staff engineer Lemelen: Since there is no interest from the tactical point of view the OKL chief of TLR/G4 has not renewed the development contract for the passive apparatus "Radiusohen".

Prof. Gladenbeck: That is a pity, since this is the most advanced development of electrical homing apparatus.

Dr. Lüschen: If G4 has no interest in the further support of the Radiusohen development, the special committee can recommend its continuance if considered necessary.

Finally Dr. Hilgers reported on the work of the subcommittee on remote control and stabilization. The work of this sub-committee began somewhat later than that of the other subcommittees so that a decision as to the relative importance has not yet been made.

The work of the subcommittee is divided into three parts:

(1) Unification of the controls and servomotors for flying bombs, torpedos and gliders.

(2) Standardization of electrical circuits on flying bombs.

(3) Cultivating a project relating to the connection of homing devices to the controls, especially of glide bombs and pursuit devices.

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On the first point it may be stated that today three kinds of controls are to be distinguished, namely, the pure electric, the pneumatic in which the control surface position is correlated to that of the transmitter, and those controls in which the control mechanism consists only of magnets which act on the control surface itself with full deflection. The last named type presupposes control projections or spoilers as the control surface. A unification of these systems is to be earnestly attempted with respect to questions of manufacture, thrust, and material. The pneumatic control mechanisms have the advantage of small time constants and large forces with the fault of no saving of material. Electrical controls have an advantage, the simple circuit, the freedom from temperature effects, as well as the advantage of not having to convert from electrical to pneumatic circuits. If one uses only magnets as control mechanism, this type represents without doubt the simplest and cheapest form. It requires special controls, however, which are not always applicable.

On the second point it may be stated that the circuits usually have two voltages, a 24 volt and a high voltage side. The 24 volt circuit is supplied either by storage batteries or by a generator driven by a propeller in turn driven by the relative wind.

On the high voltage side, current for driving various amplifiers is supplied by plate batteries, transformers, or likewise from a wind driven generator. From the standpoint of insulation, high frequency techniques, and load carrying capacity a simplification of the electrical circuits is to be attempted with special attention to the factors just mentioned.

On point 3 it may be stated that the question here is of the working out of a project. The connection of homing devices to the controls of a missile is a problem which presents a very large number of difficulties. Until now connections of homing devices to controls have been projected by various groups but not yet carried out or practically tested. The subcommittee has therefore considered its most important task to be that of realizing such a combination with the greatest speed. Therefore, at the suggestion of the subcommittee, several homing devices have been developed, which will be completed at the end of this month and which are for the purpose of studying the control network. These devices which are equipped at first with caesium cells, are the forerunners of pure infrared devices with Elac cells and are so shaped that after successful drops of the first missile infrared equipment can be installed. The subcommittee hopes that by the middle of next month the

first complete control will be demonstrated in which the Henschel air frame Hs 293 will be used with respect to attacks on ships.

In the discussion Dir. Wilde inquired whether it would not be better to conduct the first experiments with airplanes instead of with missiles. Dr. Hilsers remarked that such proposals had already been made but that the decision had been made against this procedure, because the relationships in gliders would give quite a different picture because of their low speed and in powered flight additional complications arise from the very large mechanical and acoustical vibrations and also the mechanics of flight of aircraft are quite different for airplanes as compared to rocket driven bombs. Staff engineer Imseler asked in reply with regard to the conduct of the experiment and with regard to the connection of the devices on two and four finned missiles (airplane and bomblike missiles), which were answered in detail by Dr. Hilsers, that the first devices were provided for "one day" experiments to simplify the testing and to decrease the fuel consumption. With regard to connecting the devices, it was mentioned that the connection of homing devices to bomb-like missiles was fundamentally the simpler technical problem, that however with the larger number of existing airplane-like missiles one must immediately attack this problem, especially since at present no bomb-like missile was available for immediate tests, if one disregarded the very heavy Fritz X which could only be released at a high altitude. Obviously the development of homing devices had to consider this device also in order to be able to connect to this device in its final stage as well as to X4 in the first instance.

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Then followed a discussion of power requirements, batteries, etc.

Meeting of November 8, 1944

1. Report on the present state of proximity fuses and homing devices.

Prof. Gladenbeck introduced Dr. Weiss, who had accepted the chairmanship of the subcommittee on Countermeasures against Enemy Homing Devices. Dr. Weiss requested the Services and the Army in particular to put at his disposal as quickly as possible all material on enemy devices. Reports are to be made to the office of the Special Committee on Electrical Components of Munitions. Prof. Küpfmüller requested cooperation in this

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question with the Central Office of Technical Radio Information, Dr. Bode (Plenipotentiary for High Frequency).

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Runge reported on proximity fuses.

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Dr. Runge reported on homing devices.

The development "Dogge" (acoustic) was undertaken for the X4 missile. It is planned to cut off the propulsion after a certain time of flight. Dr. Remecke showed a microphone with built-in amplifier. For X4 (a missile with rotation) two such microphones are used which are installed diametrically opposite each other. Telefunken-Messerschmitt microphones are used. It is hoped to obtain ranges of about 1000 meters. In addition to "Dogge" there is a further development "Lacha". The error signals are obtained by periodic switching. In this way there is a saving of tubes. General measurements are in progress at Elac by Dr. Hecht. On this side there are favorable results of measurements on microphones which however are subject to reservations. Dipl.-Ing. Muck is working on a third acoustic development.

The development of electrical homing devices lies essentially in the hands of the Post Office Research Department. Of these developments the device "Lorlz" works with the interference field which is found around a target illuminated by a stationary GW transmitter. The error information is obtained from the midpoint of the interference field. The preliminary testing has given good results. In addition there is in progress among these a pulse device, which however has not advanced as far.

Of optical homing devices the first to be named is the device "Linse", whose range against various sea targets has been tested as 1600 m. The angle of view is ±10°. At present, the device lacks seaworthiness. The conversion of the output of the device to control signals has been solved by the firm Askania. An attempt is being made to increase the field of view without limiting the range. In addition, the rotational speed of the scanner will be increased.

Besides the current developments "Baden" and "Hamburg" on whose manner of operation Dr. Kutscher reported separately, two additional optical developments or contracts had been

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awarded in the interim to Askania and LGW. Also in the meantime it has been determined with respect to the LGW contract, that these ideas have already been considered in existing developments, no further data are available as to the current development at Askania.

Further experiments are in progress on the development "Pinsel". In the discussion on homing devices Staff engineer Bree called attention to the bad rotational characteristics of X4 with regard to the "Dogge" device. According to the previous experiments the rotational frequency varies between 4 and 1 or finally even to 1/2. It has been determined that a rotational frequency of 4 is most desirable. To a question on power requirements Dr. Seneske gave the total consumption of the "Dogge" device as 25 watts. A suitable battery is available.

In connection with electrical homing devices the "chaff" question was discussed. According to the view of Chief Staff engineer Bree the continuous jamming of air-launched devices by "chaff" was much more difficult than ground-launched. Bree recommended, therefore, that the transmitter be placed on an airplane. Against this, Dr. Runge pointed out that then ground reflections came into the picture in a disturbing way. Prof. Küpfmüller suggested that experiments be also made with beams against sea targets.

Oberpostrat Weiss called attention to a contract of Chief staff engineer Cromoli who considered a simple television apparatus (about 7 tubes) as possible for flak rockets. Simplification should obviously be possible by producing the synchronization by the radar method.

Prof. Kupfmuller made a proposal to use Rumbauske's device and similar tracking devices as target indicating devices.

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Discussion of tubes, fuse safety devices, etc.

2. Report on the work of the subcommittee on stabilization and control.

Dr. Hilgers reported as follows:

The work of the committee has related to the survey of of existing and projected controls and on working out a project for the connection of target seeking devices to the controls of missiles.

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With regard to unification of controls, investigations have been made by Chief engineer Thiry which have been assembled into a special report. These investigations relate to the status of present developments and show the satisfactory result, that the development of apparatus in this field has progressed so far that practically any regulating task can be practically solved today with existing methods.

To the question raised at the last meeting whether electrical or pneumatic or hydraulic control mechanisms are most suitable, the report gives a statistical review. It likewise contains valuable compilations of the missiles provided with course steering, two and three axis controls.

With respect to the connection of homing devices to the control of glide bombs Dr. Hilgers showed an optical homing device developed by AEG, which serves as a start for testing of controls. This has been completely developed for the manufacture of a small series and has for a field of view of ±20° a range on 5 Km or more by day and a light source located on the ground. The device is so developed that it can give tracking in Cartesian and polar coordinates and shows excellent characteristics for testing controls with a sensitivity of ±0.1 to ±0.15°.

In general, for the test of homing devices, in accordance with the report at the last meeting, a ground launched missile has been developed [code name, "Steingels" later changed to "Springbock"] and built. Such a device was exhibited. Attention was called to the fact that this device possesses a comparatively very powerful control in order to be able to carry out more positive tests. The device was developed as a bomb-like missile. The weight with controls, but without target seeking head is not quite 20 kg. Finally attention was called to the various possibilities of connection and the necessity of a pre-stabilization because of the limited range of the missile and numbers were given as to the release angles which must be maintained.

In the discussion Prof. Küpfmüller raised the question whether tests should be made with this experimental device and whether this device with slight modifications could be used from patrol vessels against enemy ships. He offered to permit testing on the coast near Gotenhafen since he considered the test conditions especially favorable there and more favorable than at the firing ground provided for the tests in the mountains. The question whether the device can be applied to attacks on ship targets remains to be answered.

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Identification of Persons Mentioned

Dr. Gladenbeck, Chairman of the Special Committee on Electrical Components of Munitions. (Other members are Dr. Runge, Dr. Riedel, Obering. Schuchmann, Dr. Benecke, Dr. Kutzscher, Dr. Bittel, Dr. Buch, Dir. Storch, Dr. Seiler, Dr. Reichelt, Dr. Böhm, Dr. Hilgers, Dr. Weiss).

Dr. Runge, Chairman of Subcommittee on Proximity Fuses and Homing Devices. (Other members, Dr. Benecke, Dr. Riedel, Dr. Dzwiewior, Obering. Schuchmann).

Dr. Hilgers, Chairman of Subcommittee on Stabilization and Control. affiliated with AEG.

Dipl.-Ing. Böhm, Liaison officer on electric power supplies.

Dr. Grützmacher, physicist at Physikalische-Technische Reichsanstalt, working in acoustics.

Dr. Rambauske, Ges. f. Forschung and Entwicklung.
Dr. Benecke, Telefunken Elec.
Dr. Riedel, Rheinmetall Borsig.
Obering. Schuchmann, Siemens and Halske.
Dr. Bittel, Askania.
Dr. Buch, AEG, shipbuilding section.
Dir. Storch, Siemens and Halske.
Dr. Weiss, Heeresanstalt Peenemünde II.
Dr. Kutscher, Zinc.
Oberbaurat Johannsen, Waffen Prüfstelle Bu & SK.
Fl. Stabs-Ing Brez, Oberkommando der Luftwaffe, Chef Technische Luft-rüstung, Flak, E9. (In charge of guided missile work for airforces).
Fl. Stabs-Ing Immelen, from section T4 of Chef TLR, Flak.
Dr. Lüschen, Chairman of Main Electro-technical Committee in Speer organization (Ministry for Armament and War Production).
Dir. Wilde, Askania.
Prof. Kupfmuller, Torpedo commission, WEM.
Major General Heydenreich, Chairman of Committee on Fuses in Speer organization.

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5. Appendix 3
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Abstract of UM 3580
Progress Report of Deutsche Forschungsanstalt fur Segelflug
for the period December 1, 1943 to March 31, 1944.

The DFS is organized in 5 divisions (Institut) and 2 special sections (Abteilung), devoted respectively to Aerodynamics and Mechanics of Flight, Flight Equipment, Flight Tests, Airplane Construction, Physics of the Atmosphere, High Frequency, and Special Propulsion Devices.

The Division of Aerodynamics and Flight Mechanics reported on the following work:

1. Wind Tunnel Measurements.

   Me 328 (An airplane using the V-1 aeropulse motor for propulsion)

   Hs 293F (a later version of Hs 293), control surface measurements, roll damping in autorotation tests, tests with wings of aspect ratios 3/4, 2, and 3.

   DFS 332, a glider.

   Wake measurements behind a yawed propeller.

2. Circular Test Track.

   Friction tests of metal on concrete.

   Friction of skids on snow.

3. Device (released from aircraft) UKW "Seeschwan"
   This device was fitted with air braking surfaces. It is being tested by the Air Force. It is hoped to reduce the tail surfaces to caliber size.

4. Dropping of Equipment and Supplies from Aircraft.

   Use of parachutes and rocket braking devices.

   Rigidly towed fuel tanks.

5. Theoretical Investigations.

   Theory of "Catch" (Fang) diffusors.

   Pressure distribution on non-elliptical fuselages.

   Theory of airfoil grids taking into account the thickness of the sections.

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The Flight Equipment Division reported the following activities:

1. Tests of infra red telescope.
   There is still trouble with temperature effects which distort the telescope and impair the picture. Likewise the receiver cells are not sufficiently uniform in sensitivity.

2. Design of compass for airplanes with steel fuselages.

3. Aeropulse investigations.
   Work delayed because Peenemünde is making tests on FZG 76 (= V-1). The work with controlled inlet blocking has been concluded.
   Control measurements are in progress on Me 328. This airplane is to be used for thrust measurements in flight at high speeds. These results must be obtained to be able to determine the maximum range and velocity of FZG 76 (= V-1).

4. Study of Flettner Control (Servo-flaps).
   The stability regions, frequencies, and damping were computed.

5. Tests of FZG 76 control instruments. (V-1 controls).
   Tests showed that the tolerances on the Askania control can be relaxed to permit easier manufacture. Leather valves can be used in the servo in place of metal if properly lubricated with graphite or a special oil.
   The construction of the damping gyros can be simplified.
   The construction of the free gyro can not be cheapened.
   A device for measuring the lag of the control has been constructed.

6. Lateral stability of BV 246.

7. Enzian. (an anti aircraft rocket propelled missile developed by Messerschmitt).
   Responsibility has been assumed for the gyro and control system and the stability computations for Enzian. An automatic control is being designed.

8. Missile Flight Simulator.
   A model set-up simulating missile flights has been arranged for tests for simulating control with television.

9. Feuerlilie (An antiaircraft rocket propelled missile developed by LFA Braunschweig).
   DVS is making synchronizing apparatus for this missile.

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10. Wasserfall (An antiaircraft rocket propelled missile developed by the Peenemunde group.
Tests with the missile flight simulator are being made on Wasserfall. Trajectories according to the eclipse procedure have been calculated.

11. "Gehobene Lichtmessstille".
The angle measurement is sufficiently good.
The pendulum vertical and "Ablage" telescope are being designed.

12. Photo cathodes.
Experiments are in progress to increase the sensitivity of photocathodes. Metallic and soot-like bismuth used.

13. Mechanical-electrical control device.
The gas discharge relays are acceptable.

The following projects are mentioned by the Flight Test Division:

1. "Mistel" towing experiments. DFS 230 + Bf 109E.
Test of 70 watt loudspeaker apparatus shows insufficient intensity. (Apparently a target for acoustic fuses; see later in report).
Vehicle used as transport for propaganda material, torpedos, loudspeakers, etc.
Also tested DFS331 + Bf 110 and Potez 161 + Bf 110.

2. "Lotus".
This is a self-propelled speed boat towed by an aircraft to intercept a ship target. The UB search apparatus of the Atlas Works, Bremen, is too heavy for use on aircraft.

3. "Robbe".
A device towed under the He 111 H6. The loading was established as 165 km/m^2. The pay load was 875 kg.

4. "Fangschlepp".
A method of towing gliders.

5. "Trag start"
Apparently another method of takeoff of a towed vehicle.

6. Decreasing landing run with braking rockets.

7. Towing of bomb SC 250.

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8. "Okarina"
A bomb with 5 Carlton whistles for testing acoustic fuses.

9. "Troja"
Pamphlet container for releasing pamphlets from aircraft.

10. Towing of fuel tank in which a 150 watt loud speaker was mounted.
The results were negative since the loud speaker was drowned out by motor noise.

11. "Janus"
This is a double control arrangement in the Me 110 permitting control of the fixed guns from the rear seat.

12. Test of high-altitude unmanned model.
This was a model with 20 kg weight of apparatus to be towed to 9000 meters, set free, and glide with low sinking speed.

13. Pamphlet-release chute.

14. Rigid towing of Go 242 behind He 177.

The Aircraft Construction Division mentioned the following:

1. Construction of towing connectors between two airplanes.
FW 58 and KL 25
Do 217 and Me 109

2. DFS 322.
An airplane intended for measurements at high speeds. Could not be completed before end of June.

3. Me 328.
The types V4 and V5 were displaced by other work. The landing gear on V3 has been altered and the mounting of the aeropulse motor changed.

4. "Höhenaufklärer".
Literally means "altitude informer".

5. "Beethoven".
Ju 88-?f 109? The combination has been sent to Junkers for test.

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6. Model F ?
Dynamically similar models were made with 25° and 35° sweepback.

The work of the Division of Physics of the Atmosphere mentions only two projects:

1. Stratosphere and Icing Investigations.
Tests on condensation trails with dust free vaporizers to see if dust nuclei are necessary to produce them.

2. Measurements of atmospheric electricity.

The Section on High Frequency lists the following problems:

1. Development problems in the television field.
Effect of carrier frequency on transmission. In meter wave region with Fernseh GmbH "Tonne F" an air to air range of 250 km was obtained at 4000 meters altitude. In the decimeter region directional antennae must be used because of directional effects. With the previous Yagi antenna ("Tonne A") simple evasive movements of the aircraft give bad disturbances. With a circularly polarized smooth antenna much better results were obtained. A rotating antenna was also constructed. Experiments are in progress with filters and color television for greater contrast.

2. Anti-jamming Studies.
A secure communication system using supersonic sound waves of two frequencies has been designed. Impulses are used rather than continuous waves. Jamming of one frequency does not interrupt the communication.

The Division on Special Propulsive Devices reports on the following projects:

1. Intermittent jets.
Developments include automatic valving, a new Bosch injection apparatus, compressed air hammer injection, and controlled valving.

2. Continuous jets.
Numerous calculations were made on ram jets, and preparations for towing experiments are in progress. Reference is made to UM 3509. The theoretical results indicate a climb to 12000 meters in 2 minutes. Reference is also made to reports on Flight Performance Calculations of an Extremely Fast-climbing Ram-jet Pursuit Airplane and on Suitability of the Ram Jet for Unmanned Missiles. The use of the ram jet on

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the Me 109 is unprofitable as it costs too much in drag at ordinary speeds.

Abstract by Hugh L. Dryden, Consultant on Guided Missiles, AAF Scientific Advisory Group.

Appendix 4

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Bibliography of ZWB Reports on Missiles
(Incomplete)

Forschungsberichte

FB 1065. Lateral stability and lateral deviations of the trajectory of gliders with fixed controls left to themselves, by Standing.

1123. The complete longitudinal motion of a glider with fixed controls left to itself after a disturbance of a steady condition of flight, by H. Göbel.

1138. Calculation of the curvature of the trajectory and attitude angle of a glider with imperfect symmetry left to itself, by G. Plato.

1240. Aerodynamically favorable shapes for unpiloted gliders, by Plato and Jenk.

1243. The status of the DFS development program on glide-missiles of large weight and small span, by J. Lennertz.

1625. Stabililization of the rolling motion of missiles and aircraft torpedos, by Korris.

1641. Longitudinal motion of a glider (missile) controlled by a "variometer", by Naumann.

1692. Investigation of glide angle control, by Friedrichs.

1717. Development of spoiler control for remotely guided missiles, by Ernst Kramar.

1798. Bomb and torpedo weapons for use against ship targets, by Hipp.

1819. Investigation of the lateral stability of a glide bomb with an automatic control without lead, by Sponder.

1829. Departure of guided missiles from the pursuit curve, by Leisegang.

1830. Model investigation with targets and missiles according to the eclipse procedure, by Fischel and Bach.

1831. Results of model experiments with targets and missiles according to the eclipse procedure, by Fischel and Bach.

1832. Trajectories of guided missiles in the plane of the course, by Fischel.

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FB 1847. Investigation of the beam guiding of a flak rocket, by Correll.

1892. parts 1 to 9. Investigations of the stability of beam guided flak rockets, by Hoch and Lyra, Hoch, Hoch, Lyra and Schuler, Hoch and Müller, Hoch and Brankamp, Lyra and Hoch, Hoch, Lyra and Hoch, respectively.

1897. Model experiments on aiming missiles with the aid of television equipment, by Staiger.

1925. Trajectories of missiles remote controlled according to the eclipse method, by Leisegang.

1958. On the suitability of the Lorin drive (ram jet) for unmanned missiles, by Sänger.

1971. The longitudinal motion of missiles with homing control, by Truenfels.

1999. Pursuit curves, especially accoustic ones, by Gerbes.

2010. Approximation formulae for calculating the trajectories of bombs with lift, by Pflanz.

Untersuchungen und Mitteilungen

UM 650. Some types of pursuit curves, by Dobbrack and Knothe.

684. Advantages of winged aircraft torpedos as compared with other types of bombs, by Braun and Retert.

697. Experiments on the recovery of high speed missiles, by Retert.

709. Investigation of methods of recovery of unmanned missiles, by Hipp.

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