SECRET **A. D. I. (K) Report No. 390/1945**

THE FOLLOWING INFORMATION HAS BEEN OBTAINED FROM P/W AS THE STATEMENTS HAVE NOT AS YET BEEN VERIFIED, NO MENTION OF THEM SHOULD BE MADE IN INTELLIGENCE SUMMARIES OF COMMANDS OR LOWER FORMATIONS, NOR SHOULD THEY BE ACCEPTED UNTIL COMMENTED ON AIR MINISTRY INTELLIGENCE SUMMARIES OR SPECIAL COMMUNICATIONS.

RADIO AND RADAR EQUIPMENT IN THE LUFTWAFFE – X.

German early warning Ground Radar.

1. This report is the tenth of the series dealing with radio and radar equipment in the Luftwaffe. As in the case of the previous nine reports (A.D.I.(K) 343, 357, 362, 365, 369, 370 and 330/1945), it is based on interrogation of General Nachrichtenführer MARTINI, Director General of Signals, and some members of his staff, and has been supported by a number of relevant documents of recent date which were in the possession of the General's Chief of Staff.

DEVELOPMENT OF EARLY-WARNING RADAR.

Early History.

2. As recounted in A.D.I.(K) 343/1945 and again mentioned in A.D.I.(K) 365/1945, the Freya, which became the first standard early-warning radar set for the G.A.F., was developed by the firm of Gema, Berlin, with the encouragement of the Navy. The first Freyas were in operation as naval coast watchers in 1938 at a time when the G.A.F. was only thinking of radar in terms of searchlights and Flak.

3. The Technisches Amt wished to push 50 cm. wavelength like that of Würzburg, but the Navy backed the longer wavelength of Freya, and General MARTINI, who immediately appreciated the advantage of a wide-angle apparatus of Freya type to early warning, asked that a number of Freyas should be allocated to the G.A.F.

4. In early 1939 one of the present P/W, Oberst Ing. HENTZ was selected from among the Köthen staff to take charge of the first experimental Freya used by the G.A.F. in that year. It was thought at first that the Freya would only give indications over the sea, but during the march on Prague in the first part of 1939 an experimental Freya was set up in the Riesen Gebirge in order to watch Czech aircraft which might

react to the German advance. This experiment was not a success, as the signals operators had not been expecting to find their tube cluttered up with permanent echoes.

5. At the outbreak of war the G.A.F. possessed eight Freya stations distributed round the East and North Frisian islands guarding the Heligoland Bight and the approaches to the North Sea ports. These Freyas proved their value during the early Bomber Command raids on Cuxhaven and Wilhelmshaven etc., when some outstanding successes were registered by German fighters, which were vectored on to the bomber formation as a result of the early-warning obtained by the Freyas. It was this success which convinced the G.A.F. of the practicability of radar as an early-warning device.

Early Developments.

6. The range of the early Freya was of the order of 80 km and their accuracy of the order of a few degrees. No height finding facilities were available. The height finding problem at close range was solved by directing a Würzburg on to the target when it came within the range of the latter, which in these days was about 30 km. This system of height measurement continued to be the only practical one for a long period, although the field operators had put in requirements for height finding Freya apparatus as early as 1940.

7. Experiments by the G.A.F. produced the Wassermann, but the German Navy experimented with the object of introducing height finding facilities in the Freyas, and the N.V.K. at Pelzerhaken produced the "Chinese" and "Tiefland". The former gave maximum location by means of a compensator in an serial system inclined at 45° and was used for angles greater than 15°, whilst the latter was intended for angles less than 15°. The combination of the two mounted on the Freya was known as the “Malaya”.

8. Measurement of height with the Tiefland was possible between 2° and about 15° over level terrain; measurement of angles of less than 5° was, however, very inaccurate and range was actually less than that of the Würzburg-Riese. Over uneven terrain, measurement of the vertical angle was impossible.

9. The Tiefland had the disadvantage of being complicated in operation - a large field of reflector nets was also necessary - in addition to which it gave no better performance than the Würzburg-Riese. Its use would only have been justified had it been a device which could be moved easily and quickly and had there not been restrictions on the selection of suitable sites for its mounting.

10. Freya Fahrstuhl was designed by Köthen as early as 1943 but was never put into large-scale production, and was not satisfactory. This apparatus depended on the difference of phase observed between direct ray and ground reflection to give height.

11. Finally, in 1944 methods or swinging the beam electrically were used in the Wassermann for height measurement, but the Würzburg remained the basic means of measuring the elevation up to the end of the war. The D/F accuracy of the Freya was greatly improved when the split beam or A.N. technique was introduced in 1942, end this made Freya valuable for fighter control on the Egon system.

12. The range of Freya, naturally dependent on height of an objective, was about 150 km. but this was not considered sufficient for the early-warning service and efforts were made in 1942 to produce early-warning apparatus with greater range. The first of these was the Wassermann which improved the early-warning range to about 200-250 km, while the Mammut, used by the Navy for coast watcher purposes, was also used by the G.A.F. and gave ranges up to about 300 km. Finally Elefant, which gave ranges up to 350 km., was built and came into operation in about 1944.

13. By the middle of 1943 an elaborate early-warning service covering the whole of Germany and composed of sites with both Freyas, Würzburgs and Giant Würzburgs had been built up, and a number of Wassermann chimneys were in operation along the coast of Europe.

14. The great improvement in D/F accuracy resulting from the split beam technique was utilised by KAMMHUBER to develop his box system of night fighting, and in fact at this time it was strictly forbidden for a night fighter to fly any form of night defence other than the close control of the KAMMHUBER box system.

15. Other methods of fighter control namely the Egon and Bonito, were under development, and of these the former also used the Freya wavelength for range and D/F.

Effect of first use of Window.

16. When Window was first used in July 1943 the whole of the early-warning system as well as the night fighter control system broke down completely.

17. The first German reaction to the use of Window was to attempt to filter it out or obtain some method of distinguishing between blips due to window and those due to

the aircraft itself. Virtually no work had been done on this problem before July 1943 because GOERING had been so frightened by the prospect of Window being used by the enemy that the theoretical possibilities had been hushed up and scientists has not being allowed to work on the problem (cf. A.D.I.(K) 334/1945).

13. Nevertheless, when Window was first used by the Allies, it was only a matter of some ten days before the first solution to the Window problem for the Würzburg was forthcoming in the shape of the Würzlaus, which relied on the Doppler effect. High priority was given to the problem and even money prizes were offered for solutions.

19. Three main types of equipment were evolved as a result of the various solutions proposed; one was Taunus, which gave greater blip resolution, another was the propeller modulation type such as Nürnberg and the third was based on the Doppler effect, the latter being termed Laus A—J devices. Of these the Freyalaus for Freya and Wasserfloh for the Wassermann were not used operationally till 1944.

Effect of Further Countermeasures.

20. As Allied countermeasures became more intense and electronic jamming was also used, the signals staff decided that it should be the genera1 policy to provide all types of radar with the facility for a change of frequency. The first efforts to do this were brought about by mechanical trombone tuning of the aerials so that two or three neighbouring wavelengths could be used. This was termed the WISMAR principle.

21. Sometime in 1943 Dr. SCHULTER of the firm Siemens developed the Breitband (wide band) aerial which enabled a much greater frequency spread to be used. This principle was termed Voll Wismar and with increasing experience was to be applied to all types of ground radar. At the same time Freya and Würzburg were allotted different "Inseln" or frequency bands in the hope that some of these bands would not be jammed locally. This policy was carried to great lengths, but Allied countermeasures still remained extremely effective.

22. Either owing to the weakness of German centimetre technique, or to a lack of appreciation of the value of centimetre wavelengths, the main trend in avoiding British countermeasures was towards longer wavelengths, and special Köthen Freyas using wavelengths of 5 and 8 metres were prepared. When jamming on the more normal wavelengths

became severe these reserve sets were operated for a minimum period often only a few seconds, in order not to compromise the wavelength, and an effort was made to obtain a clear picture of the air situation with their aid.

23. Eventually wavelengths up to 13 metres came into use for early-warning with giant sets such as Elefant.

British Transmissions as an Aid to Early Warning.

24. Despite all these precautions, and despite the fact that P/W claimed that many of these wavelengths were not effectively jammed, it frequently happened that the early-warning service was unable to obtain a clear picture of the situation and recourse had to be made to indirect means. The monitoring service was of particular value in this respect, and they successfully maintained their point of view that it was not worthwhile jamming the fighter R/T because D/F'ing of this provided excellent early warning.

25. The fact that British night bomber crews were in the habit of using Monica and H2S from the very beginning of their flights was also of great assistance in supplementing the early-warning picture. In the same way Allied I.F.F. was of great value, and special Freyas known as Freya Flamme which covered the I.F.F. frequency band were erected on some important early-warning sites.

26. Finally, an ingenious system which was invented by Oberst Postrat SCHOLZ called Klein Heidelberg utilised the reflection of the transmissions from British C.H. stations and was regarded as virtually unjammable.

Development of Panoramic Presentation.

27. As early as 1940 a requirement was put up for a panoramic presentation for early-warning radar, but no great progress seems to have been made until the discovery that H2S was using a P.P.I. successfully. Difficulties were encountered with the early types such as Propeller developed by Lorenz and it was not until early 1944 that the Jagdschloss sets came into existence. These were originally used entirely for early warning and not with the idea that night-fighter aircraft could be controlled with their aid. It was not until 1945, when the value of Jagdschloss was fully appreciated and it was numerous enough to cover 1st class radar sites throughout Germany that some efforts were made in its employment for control of night fighters.

28. With the intended introduction of Neuling I.F.F., which could distinguish not only between friend and foe but between

individual crews as described in A.D.I.(K) 365/1945, fighter control from panoramic presentation was to be greatly extended.

SPECIAL PROBLEMS AND APPLICATIONS ON GROUND RADAR.

Day Fighter Control.

29. The necessity for day-fighter control from ground radar stations was early appreciated by the Signals staff, and the Battle of Britain proved to them how successfully it could be used by air force inferior in numbers. Spasmodic attempts were made to introduce it into the G.A.F. but the German fighter tradition was too strong, and the pilots would not accept ground control.

30. It was not until 1943 that close ground control on the Egon system using the FuGe 25A in the aircraft was introduced.

Control of Night Fighters.

31. With KAMMHUBER's box system two Würzburg sets were used - one to follow the target and one to follow the fighter, the positions of each being projected on to the map by means of the so-called Seeburg Tisch. So long as there was no jamming of ground radar, this method was successful and could place a fighter within 200-400 metres of the target. Later the Würzburg Riese was used and the majority of these sets were allocated for this purpose.

32. A suggestion had been made that the Würzburg 50 cm. transmission should be used simultaneously for giving the fighter his vectors and a system named Sprechstange was experimented with. It was rapidly found that, if the operator failed to hold the fighter in the beam, the pilot received no instructions from the ground, and so vital instructions might not be heard. For this reason it was soon abandoned as not practicable.

I.F.F. Problems.

33. The FuGe 25A was originally designed by the firm of Gema for use with the first Freyas operating on 2.4 metres. As recounted in A.D.I.(K). 365/1945 it became the standard German airborne I.F.F. set in 1942 and was used with the Kuh transmitter and Gemse receiver on all ground radar installations, whatever the wavelength, with the exception of the Würzburg series. A full description of the problems of ground radar has been given in the above-mentioned report.

Plotting of High Flying Aircraft.

34. In 1944 it was found that the very high level Mosquito bomber attacks on the Reich sometimes crossed the coast unplotted, and at best were only detected intermittently after passing the coastal screen of Wassermanns which could swing their beams upward electrically. The reason for this was that the main lobs of Freya only went up to about 8,000 metres. There were two subsidiary lobes, the higher of which reached to 12,000 metres, but the latter only gave limited coverage at this height over an estimated range of 70 km.

35. The Würzburg beam was too narrow and did not give general coverage, while Freya Fahrstuhl, which could also be utilised for aircraft flying at great height, had hardly been introduced into operations. For this reason considerable use was made of the Würzburg Riese-G which was a Giant Würzburg with a very narrow 50 cm. beam, with additional Freya aerials on 2 metres, set in the paraboloid, giving a wide beam coverage as well. As the circle paraboloid could be tilted upwards, excellent high coverage was obtained and high fliers were plotted with its aid.

Plotting of Low-Flying Aircraft.

36. The Germans were fully aware of lack of low cover, which enabled aircraft flying low over the sea to cross the coast unnoticed. A number of experiments were conducted to overcome this disadvantage by placing special aerial arrays at considerable height above the ground as for instance in the case of the Würzmann using the Würzburg frequency and the Tiefentwiel using the Hohentwiel A.S.V. frequency.

37. Some experiments were also conducted with wavelengths of about 20 metres with the idea, it was believed, of making use of the curved path which those waves followed. The experiments were never completed, as this band was interfered with by communications signals transmitted on the same wavelength.

38. Experiments had also been made at Köthen with Taunus equipment coupled to the Freya to obtain extremely high resolution. A Fieseler Storch aircraft was used, flying at 150 metres over flat country, and under these conditions the aircraft could just be seen at ranges of 4 or 5 km. through the ground returns due to woods and houses. It was concluded, however, that this range was so small that no advantage was to be gained.

GROUND RADAR INSTALLATIONS.

Freya.

39. Freya was manufactured by the firm of Gema, Berlin, which, at the outbreak of war, was only a small establishment largely financed by the Navy. Members of the Technisches Amt, as well as of MARTINI's staff, criticised the firm, severely, saying that they lacked experience of manufacturing and were unwilling to make themselves adaptable. They described the Freya Stand for instance as a "cast iron monstrosity", which they felt could easily have been made very much lighter in weight and manufactured more simply.

40. Despite this complaint against Gema, it was a principle that all ground radar apparatus should be of fairly simple construction so that it could be made mobile. A few days after the invasion of Norway the Germans were experiencing considerable trouble from bomber raids in the Stavanger area and an urgent request was sent out from there for a Freya to be supplied. This job was given to one of the present P/W, and within three days of receiving it a Freya LZ Stand had been dismantled and packed into three Ju.52's and transported to Stavanger. Eight days after the reception of the order the Freya was operating.

41. At the beginning of the war the G.A.F. possessed eight Freyas. At the end of the war over 1,200 had been manufactured and a document dated 1st January 1945 states that 671 were in operation at that time.

42. Owing to the incidence of all forms of Allied jamming, the original wavelength of 2.40 metres had been modified very considerably. The following impressive list of wavelengths current at the beginning of November 1944 was found among documents brought by General MERTINI's staff:-

	M.		M.
Insel A	- 2,32-2,45	Köthenband gelb/braun	1,70
Insel B	- 2,08-2,24	Köthenband gelb/rot	1,80
Insel C	- 3,00-3,30	Köthenband Ludwig	1,95
Insel D Band Z	- 1,50-1,55	Köthenband gelb	2,00
Y	- 1,55-1,60	Köthenband gelb/grün	2,56
X	- 1,60-1,65	Köthenband grün	3,15
W	- 1,65-1,70	Köthenband rot	3,40
V	- 1,70-1,75	Köthenband braun	3,65
U	- 1,75-1,80	Köthenband weiss	4,05
T	- 1,80-1,85	Köthenband schwarz	4,60
Vollwismar			
Bereich I	- 1,90-2,50	Köthenband blau	4,80
II	- 1,20-1,90	Köthenband violett	5,20
		Köthenband grau	5,75
III	- 2,50-4,00	Köthenband blau neu	8,80

43. In addition to this formidable list P/W states that in early 1945 experiments were being made with a Köthen Freya on about 12 metres. The Köthen Freya with wavelengths of over 4 metres presented a problem to the aerial experts which was being solved by using Yagi aerials mounted above the normal aerial mattress. Although it was considered desirable to mount the aerials at a height above the ground of at least ten times the wavelength, this was not always possible; for instance the Yagi aerial of Köthen Blau (4.80 metres) was, according to a document, to be mounted 30 metres above the ground.

44. Two further new wavelengths known as the Rotschwarz and Grünschwarz were planned and were to operate on two of the frequencies used by British Gee in the hope that they would not be jammed. It was realized that these wavelengths could only be used when the jamming of Gee by Heinrich transmitters was not being carried out. The Freyas so equipped were to be located as far as possible from the positions of the Heinrich jamming transmitters.

45. In order that these longer wavelengths should not be compromised, a so-called Kurz Zeit apparatus was built into the Freyas which allowed transmission of only ten impulses and prevented more impulses being emitted for a period which could be set between 2 and 22 seconds. It was considered unlikely that listening aircraft would be able to tune to these short interrupted pulses.

46. A document, dated June 1944, in the possession of a member of General MARTINI's staff, contains a short history of the jamming experienced by Freya. Extracts from this document are given below in free translation:

"Jamming by Jamming Transmitters.

"In April 1942 the jamming of Freya on the original 2.40 metre wavelength was reported.
"On 5th March 1942 the Chef N.V.W. put up a requirement to the Technisches Amt asking that alternative frequencies for Freya should be made available, basing his request on the fact that parts of a Würzburg, from which the exact wavelength could be determined, had fallen into enemy hands during the Cap d'Antifer (Bruneval) raid on 27th February 1942. By the end of 1942 the original Freya wavelength was being jammed generally.

"As no steps to provide alternative frequencies in operations had at that time been taken by the Technisches Amt or by industry, Ln. Versuchs Regiment Köthen was asked to use its resources to provide them.

"After about one month, on 15th June 1945, the first Freya which operated in an unjammed band, the Köthen Grün, was handed over to a unit for operational use.

"In 1942, Freya on Insel B and Insel C had been demanded from the industry but they were not delivered until 1943. The Insel B sets were first available on 23rd February 1943, but shortly after being used operationally were jammed by the Allies. The Insel C apparatus was made available on 10th July 1943 and has been in regular production until the last few months.

"It must be recorded at this point that the first new Insel was produced by the industry about a year after Köthen had produced an improvised apparatus. Moreover, the Technisches Amt and industry were unable to give the Signals branch a Freya which was not jammed. Assistance had to be sought from Köthen, who produced Köthen bands which alone enabled the further operation of Freyas to take place.

"In view of the jamming situation the Chef N.V.W. demanded on 19/12/42:-

(a) Freya frequencies below 1.90 metres.

(b) A Voll Wismar band which allowed constant frequency change

(c) Long waves over 4 metres, with the suggestion that the Yagi aerial arrays should be used.

"The following comments must be made on the foregoing demands:-

(d) The first Freya below 1.90 metres (Flum 41) became available on 2/7/43.

(e) The first Voll Wismar was delivered in May 1943, but in spite of this the first mass-produced apparatus was not available until July 1944, and then only in small numbers.

(f) The problem of long-wave Freyas was never taken up by either the Technisches Amt or by industry. This problem was solved by the development by Köthen of Yagi aerials, and these were first built into operational sets in September 1944.

"Jamming by Window.

"The possibilities of jamming by Window were made quite clear on 17/3/1943 and a requirement for an anti-jamming device for

all radar apparatus was formulated. Not until 19th June 1944, that is, one year and three months later, was the Freyalaus, which had been developed by ZVH, made available by the Chef TLR.

"Since it was clear that a change-over to longer waves to avoid Window was the only possibility available at that time, the only solution was the use of long-wave apparatus (Yagi Köthen Grau). With this type of equipment it has been possible for some months to obtain an early picture free from jamming. Further Yagi wavelengths were developed and units are being equipped with them.

"To make recognition of new radar wavelengths impossible for the enemy, a short transmission system (Kurz Zeit Messung) described above was formulated as a requirement on 23/9/42. At the data of writing this has not yet been introduced."

48. The decision to avoid Window by using longer wavelengths appears to have been taken on the results of some experimental work. When Window 1.80 metres long was produced against SN2, Insel C was severely affected, and research work was done on the susceptibility of different wavelengths to Window of this length. The diagram produced in Appendix I shows the effect produced by a standard quantity of 1.80 metre Window at a range of about 70 km. on various types of Freya.

49. As a result of this experimental work, the Signals staff realised that it was an advantage to increase the wavelengths as the intensity of the signal received fell off sharply above 3.80 metres. It was considered impracticable to put a longer Window into use and as a result the so-called-Köthen bands were produced.

50. The Germans were unaware that we were dropping very long Window {rope) at a later date. A certain number of specimens of this had been picked up and it had been assumed that it had something to do with meteorological observations.

51. In an interesting publication Funkmessnachrichten No. 19 dated 25th February 1945, it is stated that the C-Insel of Freya suffered worst from jamming by ground transmitters but gelb-rot, grün, braun, weiss and grau Köthen bands and the A, B and D Insel were also jammed at times.

52. Airborne transmitters were beginning to jam the Köthen grau band, while Köthen braun and D Insel experienced occasional interference by airborne-electronic jammers. Only on one occasion had jamming of the Köthen weiss been observed from the air.

53. The G.A.F. was vitally interested in the Köthen grau band which was the main stand-by for the early-warning service, and

it was this band and the Köthen blau on 8.80 metres about which instructions had been given that they were to be switched on only for very short time in emergency. About 40 Köthen grau equipments were in operation.

54. The range claimed for Freya was 80-120 km., with a range accuracy of ±300 metres and D/F accuracy with split beam (A.N.) $^{1}/_{3}°$.

55. It is stated in the same document that by February 1945 all Freya equipments, with the exception of some motorised units, had been fitted with the Freyalaus. A new type of A-J device, which is however, not described, named the Prüflaus was at this time being tested on a few sites.

Freya Flamme.

56. A certain number of Freyas in the Insel D band were set aside for the purpose of triggering off British I.F.F. when this had been left on in aircraft inadvertently. It was claimed that, provided the aircraft was flying at a considerable height, ranges of up to 450 km. had been obtained with the Freya Flamme. D/F was difficult due to the wide spacing of the short pulses and no continuous echo being-obtained. The Germans were aware that six codes were transmitted by British I.F.F. and believed that they know the significance of the various identifications.

57. Initially this proved a most useful very long-range early warning, but the number of aircraft flying with I.F.F. had been greatly reduced during the last year of the war.

Freya Fahrstuhl.

58. The Freya Fahrstuhl, designed by Köthen, is a Freya with height—finding facilities obtained by making use of the reflected ground wave. It was first introduced in early 1943, but owing to unknown causes, a certain amount of trouble was experienced and only about eight equipments were in operation on 1st January 1945. The original requirements were formulated in 1940 for a Freya type apparatus to give elevation.

59. This set had a range of 220 km. and was used for height finding by the early—warning service and also as an aid to Flak if the Würzburg were jammed. The wavelength used was 2.00 metres (Köthen gelb). The Freya Fahrstuhl was originally intended as an early-warning radar giving height, but the few produced were largely used to give height to Flak when the latter's Würzburg was jammed.

Würzburg.

60. The history of the development of this apparatus will be told more fully in the next and final report of this series

which will deal with German Flak radar, for which purpose it was originally designed.

61. The original Würzburg Insel A had no split beam D/F but was nevertheless used for early attempts to control night fighters.

62. The frequency used by Würzburg A was a single spot frequency, between 53.0 and 54.2 cm. It was first introduced in any quantity for raid reporting purposes in the autumn of 1940, when it was used to obtain the height of aircraft observed on the Freya. Its maximum range was about 25 km.

63. The next type introduced was the Würzburg C with A.N. D/F facilities and range of 25 km. The first Würzburg C's came into service in the summer of 1941. A few were used for controlling night fighters, but the great majority was used by Flak. The Würzburg C's were on fixed frequencies in the band 53.0 to 54.2 cm.

64. The final form of Würzburg, the D, had still only a 25 km. range operationally, but was a general improvement over the C with split D/F facilities giving an accuracy of ± ½° and range accuracy of ±50 metres. It was introduced in the autumn of 1941 believed to have been used for Flak purposes only.

65. The original sets were in the frequency band known as Insel A 53.0 - 54.2 cm but later a B band from 56.7 to 58.0 and a C band from 62.3 to 63.8 were introduced.

66. Finally a Würzburg was manufactured with wide band aerials using the Urechse equipment which allowed any wavelength between 53.0 and 63.8 cm. to be used. The Urechse transmitter was being generally introduced in the spring of 1945.

Würzburg Riese.

67. The Würzburg Riese was introduced in 1941, and from the beginning was mainly used for the close control of night fighters on the Himmelbett system. In all, 452 sets were in operation on 1st January 1945. A few sets were used for providing the Gross Batterien, situated at Berlin and other places, with information for their anti-aircraft operations, but these were of the Riese G (Gustav) type with Freya aerials incorporated in the paraboloid, so that a 50° wide search beam was provided as well as the 13° main beam on 50 cm.

68. The wavelength used for the Freya section of the Riese G was originally 2.20 Metres, but wavelengths of 1.80 metres and 1.70 metres were also introduced, and it was intended to use 1.60 metres in the future. The Würzburg section of the Riese used the A and B Insel of the Würzburg bands, namely 53.0 -

54.2 cm. and 56.7 - 58.0 cm. The range of the Würzburg Riese was about 70 km. and its range accuracy was of the order of ±50 metres.

69. Some ten of the sets used for Flak were provided with Voll Wismar using the Schwarz Echse transmitter on a new wavelength of 1.50 metres.

70. The additional Freya wavelength was found to be particularly valuable against U.S. day bombers, which usually only jammed the Würzburg 50-60 cm. band and left the Freya band unjammed.

Wassermann.

71. The original purpose for which Wassermann was introduced was to obtain a more powerful early warning radar with a greater range than Freya, and it was therefore the G.A.F. equivalent of the novel Mammut. Three main types of Wassermann were produced, the L, S and M.

72. The Wassermann L (Leicht = light) was produced by Gema and was said to have a range of 200 km., an accuracy in D/F of ± ½° and in range of ±5 km. The first set came into use about the summer of 1942; two types were manufactured, namely L.I, on 2.40 metres and L.II on 2.01-2.27 metres, in which spot frequencies (Streuwellen) at 15 mc/s intervals were available. About 25 of these were built. They were constructed as lightly as possible so that they would be transportable, which was considered specially important for the Balkans and in Norway. It was estimated that they took about 3-4 weeks to erect. They had, however, a disadvantage that in strong winds the whole tower was apt to be blown over.

73. The Wassermann S (Schwer = heavy) was also constructed by Gema and its accuracy was comparable with the L, except that ranges of 300 km. were obtained. The first equipment was erected towards the end of 1942 and in all some ten became operational. The first seven sets erected (S.1 to S.7) used wavelengths of 2.40 or 2.46 metres. These numbered S.8 to 10 used 2.36 metres, 2.34 metres and 2.29 metres. These sets took something over 4 months to build, but they were at least more robust than the Wassermann L.

74. The final form of Wassermann, the M. (Mittel = intermediate) was designed by Siemens. Its accuracy in D/F and range was about the same as the other two types but a maximum range of about 220 km. was obtained.

75. The first types introduced were the M.I and M.II in the autumn of 1943. Both used frequencies in the 2.01-2.20 metre band but the M.II allowed different frequencies within this band to be used on the Wismar principle.

76. The M.III used the 1.20-1.90 metre band, and was of the wide band Voll Wismar type but only two sets were built, as it was succeeded in the spring of 1944 by the M.IV which gave wide-band facilities from 1.90-2.50 metres. Some twelve M.IV. were in operational use by January 1945, and more were being produced.

77. The latest form of Wassermann was to be the M.V. which was a wide band equipment working on 2.50-4 metres, of which one experimental set had been set up on the Baltic coast.

78. Since about the beginning of 1944 an electrical compensating arrangement had been built into the Wassermann which allowed the beam to be swung in elevation, and an elevation of about 15° could be obtained. The A-J device Wasserfloh with Doppler effect was fitted first towards the end of 1944.

79. Generally speaking the Wassermann was a disappointment. Production of Elefant was postponed as the original estimate of Wassermann's range, as late as autumn 1943, was that it would give 400 km. coverage. Wassermann never succeeded in giving coverage much over 200 km.

Mammut.

80. This coastal radar equipment which was known to the Allies as the "Hoarding" was really a Naval coast-watching radar of which some 8-10 specimens were operated by the Luftwaffe. It had the advantage that the polar lobe was well beamed - more beamed than the Wassermann - and, therefore, it was not very susceptible to jamming but it took about 8 months to erect and was costly and unvieldy. The comparatively narrow lobe scanned electrically by means of a phase shifter, termed a compensator. The wavelength used was the original Freya band 2.40 metres and the range achieved some 300 km. No height finding was available.

Elefant.

81. The Elefant, sometimes referred to as See-Elefant was produced by the Reichspost and was designed in part by Ober Postrat Dr. SCHOLZ. At the end of the war three equipments of this type had been built and a further three were in course of erection. The wavelength used was comparatively long, in conformity with policy of escaping the effect of Window by increasing the wavelength. Of the three sets built, two were in the 7.90-8.80 metres band, and the remaining one in the band from 10.70-12 metres.

82. A D/F accuracy of 1° was obtained and range accuracy of

±4 km. The first set was created in the summer of 1942. But it underwent constant improvement and its form was not finalised until 1944. In November 1943 the Technisches Amt refused definitely to sanction the large-scale introduction of Elefant as although a range of 400 km. was obtained similar results were expected (but never obtained) from the Wassermann. A few were, however, built by Köthen in the field.

83. In order to prevent the long wavelength from being compromised, the Elefant was only used for short periods and when the air situation was not clear to the ear1y-warning service. This was the more important as it was realised that Elefant could easily be jammed. The normal array consisted of two 100 metres high towers.

Heidelberg.

84. One of the present P/W believed that experiments were being carried out with an early warning set on a wavelength of between 18 and 20 metres which was to be called Heidelberg. He understands that jamming interference was encountered, as the set operated on the frequency band used by W/T traffic, and for this reason the project was dropped. P/W stated that it was hoped to obtain very great ranges, as the waves would conform to the earth's curvature. There may, however, be some confusion in his mind with the Klein Heidelberg system described below.

Klein Heidelberg.

85. The name Klein Heidelberg was given to a system utilising reflections from aircraft of the pulses emitted by British radar stations or by distant German stations. Strictly speaking, therefore, it was not a radar set at all.

86. The results obtained were satisfactory at the three stations used, but at the time of its invention by Ober Postrat SCHOLZ, in 1941, it was not regarded as of particular importance, as their radar was not being jammed.

87. In 1944, when jamming became serious, the Klein Heidelberg system proved of great value. Its D/F was poor but range was adequate for early warning information.

88. It was noticed in October 1944 that our 25 cycle CH stations had started to change their p.r.f. but a radio locking system was improvised within six weeks and thereafter no trouble was experienced. Tests were made to utilise the Gee pulse sources, but the system worked adequately with CH and the experiments were not pursued.

89. When he was interrogated on this matter Dr. SCHOLZ stated that he understood that the results obtained at the Römö

station were surprisingly good, despite the great distance from Great Britain.

Würzmann.

90. The Würzmann was the name given to an experimental coastal set which was to be used for the location of low flying aircraft. According to P/W, it was a Jagdschloss Michael B aerial array set up on end. The aerial array of the Jagdschloss Michael B consisted of a double row of 18 Würzburg mirrors and measures not less than 56 metres x 7 metres.

91. This gigantic erection was mounted so that the electric centre of gravity was 50 metres above sea level and produced, in fact, a Würzburg beam which was very narrow in azimuth. With its aid it was claimed that aircraft flying at 0 feet could be seen at a range of 20 km.

Tiefentwiel.

92. Tiefentwiel was the code name applied to an aerial array placed high above ground using the Hohentwiel A.S.V. set with the intention of detecting low-flying aircraft coming in over the sea. No details of the aerial array or method of operation were known but it was stated that the Tiefentwiel achieved as good results as the Würzmann, namely a range of about 30 km.

Hohentwiel Boden.

93. Funkmessnachrichten publication No. 19 announced the introduction of a short-range highly-mobile early-warning radar called Hohentwiel Boden which could be erected in 15 minutes. The set consisted essentially of the Hohentwiel A.S.V. set with an aerial array mounted on the top of a 10' high mast. This improvisation was carried out by the Ln. Versuchs Regiment Köthen, who stated that individual targets could be seen at a range of 30-35 km. and formations at 60-70 km. It was to be used in the front line to give advance warning of raids.

PANORAMIC RADARS.

Propeller.

94. Some time in 1943 the firm of Lorenz produced an idea for a P.P.I. presentation for early warning to which they gave the code name "Propeller". This set relied on extremely rapid rotation of the aerials and used a wavelength of about 50 cm.

95. Just before the set was officially demonstrated to the G.A.F. it exploded. All the apparatus was lost and the project was abandoned.

Jagdschloss F.

96. The first type of early-warning radar set giving panoramic display which come into operation in usually referred to as the Jagdschloss, although it's official designation is Jagdschloss F, to distinguish it from later types, such as the Michael B and Z. It was produced by the firm of Siemens and was first used in operations in early 1944. About 65 Jagdschloss F equipments had been manufactured by the end of the war.

97. Equipments No. 1 to 62 were of the Voll Wismar type using wide band aerials and covering the band 1.90-2.20 metres. From 63 onwards the frequency band to be covered was 1.20-1.90 metres. A document mentions Jagdschloss lang (=long) with a wavelength of 8.0-10 metres. No information about this has been obtained.

98. These sets were used exclusively by the early-warning service and gave a range of about 100 km. with a D/F accuracy of 1° and a range accuracy of 4.5 km.

99. The range accuracy depended largely on the presentation on the 40 cm. P.P.I. tube. At 100 km. the area of error was stated to be 5 x 5 km. but Köthen was attempting to improve the presentation so that blips could be read to a greater accuracy by introducing electrical range rings.

100. Another trouble that was being experienced in February 1945 was that the 50 cycle frequency at the national electric grid affected the presentation so that the blips which should have appeared as small arcs actually appeared as an arc with a wavy out-line.

101. The P.P.I. tubes produced by Siemens were being modified to avoid this imperfection while the Fernseh A.G., who also produced tubes for Jagdschloss, were working on the problem. It was believed that a new type of "Tonfrequenz" cable would be necessary. Particular attention was being paid to this point because of the difficulties in reading the tube caused by window.

102. According to a document a new type of valve called the Nullode was being introduced at this period to replace the 8D.6 diode in the Simultan unit.

103. It was proposed to introduce a selecting switch, by means of which three alternative pictures could be produced on the P.P.I. tube. The first picture showed all blips present on the tube, the second position allowed the I.F.F. to be switched in, while the third was a purely I.F.F. picture in which only friendly aircraft with I.F.F. operating came up.

104. The I.F.F. problem had not been fully solved and it is stated in a document that a separate FuGe control set is necessary to assist in obtaining unequivocal identifications.

105. In this same document mention is made of the Münchhausen system which was to use coloured photographic films to distinguish between Windows and moving targets; stationery targets would appear on the film as dark spots while moving aircraft would appear as spots with red and blue edges in the direction of movement. This system had been worked out at Werneuchen and in February 1945 the first apparatus was in use with a Jagdschloss equipment in the field. The film, however, took between one and two minutes to develop.

106. Further difficulties in the form of dead zones were being encountered with Jagdschloss and it is suggested in Funkmessnachrichten publication No. 19 that a wire netting surface with a radius of 50-60 metres should be built round the Jagdschloss in order to get rid of the lower dead zone and to aid in increasing the range against high flying aircraft. It is stated that one ton of iron wire netting necessary for each site.

107. According to P/W the electrical jamming of Jagdschloss was never very severe, particularly as it had Voll Wismar. The fact that it was causing trouble was, however, proved by the fact that in Funkmessnachrichten publication No. 19 it is stated that a number of special cameras had been provided and were in use at various Jagdschloss sites to take pictures of the type of jamming encountered in order to ascertain what measures could be undertaken against jamming.

108. A so-called electric lens was to be used as a means of seeing through Window. This was an arrangement whereby a magnification of between 2 and 3 times natural size could be obtained of a circular area of the picture. The area which could be magnified could be chosen but was limited to circles whose circumference passed through the centre of the tube, but did not reach the edge of the 40 cm. P.P.I. tube.

Jagdschloss Michael B.

109. A ponderous aerial array of two rows of eighteen Würzburg mirrors measuring 56 metres long x 7 metres high was used in the Würzmann experimental early-warning radar, and formed the serial array for Jagdschloss Michael B with the array in a horizontal position. The wavelength employed, was that of a Voll Wismar 53.0-63.8 cm.

110. By means of this aerial a beam of ½° horizontal width was obtained and a range of about as much as 250 km on single

aircraft was expected. It was also expected that the narrow-beaming of Michael B would be of great assistance in avoiding Window. The dead zones were to be overcome by switching the frequency to another wavelength in the Voll Wismar band II, which was believed to run from 50-60 cm. The first set was to be ready in April 1945.

Forsthaus F.

111. This apparatus was designed by Telefunken to fulfil the same purpose as the Jagdschloss Michael B using the so-called Euklid 25-29 cm. waveband employed by the Navy. Once more a very long aerial array 48 metres long and about 8 metres high was used, employing a cylindrical paraboloid. A wave guide antenna (Hohlraumstrahler) was placed along the focal line with a second and a third wave guide parallel to it above and below respectively. The object of these two supplementary wave guide aerials was to provide displaced beams and so avoid the dead zones. A range of 220 km. was expected against single aircraft but no details were available as to whether it had come into operational use.

Forsthaus KF.

112. In order to introduce as rapidly as possible a panoramic early-warning radar in the West on a hitherto unused wavelength, a smaller form of the Forsthaus F called the KF was to be introduced while the F was being completed. It was planned so that it could be used on a railway wagon; the revolving aerial array was only 24 metres long and it was expected to give a range of 120 km. The wavelength and electrical circuits used were exactly the same as in the Forsthaus F.

Dreh Freya.

113. This set, which was also known as Freya Panorama, was first introduced in June 1944. It consisted of a Freya aerial of the Breitband type working in Bereich I (1.90-2.50), the frequency of which could be adjusted at will. The aerial was so built that it rotated through 360° and gave a remote panoramic presentation. About 20 equipments were in use in January 1945. The range claimed for it was only about 100 km.

Jagdhütte.

114. This apparatus, which was produced by Siemens, gave a panoramic P.P.I. display of the German I.F.F. responses, using 24 metre or 36 metre rotating aerials. The wavelength employed was 2.40 metres and it was planned, with its aid, to trigger off the FuGe 25A. In this way friendly fighters were to be

controlled from the ground at ranges up to about 300 km. It was fully realised that if the FuGe 25A frequency was ever jammed the Jagdhütte would be useless, but it was not considered likely that the Allies would attempt to jam it.

115. On the 1st January 1945 the first Jagdhütte equipment was being erected, and it was expected that production would amount to two per month thereafter. At the end of the war about 8-10 were being built, but there is no information as to how successfully they were employed.

Jagdwagen.

116. Jagdwagen was designed as a mobile Panoramic radar to control fighters at close ranges immediately behind the front. It was a project of the firm of Lorenz. The aerials were considerably smaller than the Jagdhütte, the array being only 8 metres long. The aerial array was to be mounted on the Kumbach stand as used in the Egerland Flak set. The frequency bend used was that of the A.S.V. set Hohentwiel namely 53-59 cm.

117. The horizontal beaming was of the same order as that in the full Jagdschloss F, namely about 6°, and ranges claimed for it were of the order of 40-60 km. for medium heights. A small P.P.I. tube of about 15 cm. diameter was used.

118. In February 1945 the first sets were being tried out at Werneuchen but it was hoped to produce the Jagdwagen, in series, as a fully mobile panoramic set operated by a motorised company to install them on aerodromes so that a picture of the local air position could easily be obtained.

Jagdschloss Z.

114. The Jagdschloss Z was the centimetric form of Jagdschloss, which was in development by Siemens; the rotating aerials were to be about 24 metres long. These sets were to give an extremely narrow beam and so offer protection against jamming. The range expected was of the order of 100 km., and although the first experimental equipment had been built it was not expected that sets would came into operational use until the autumn of 1945.

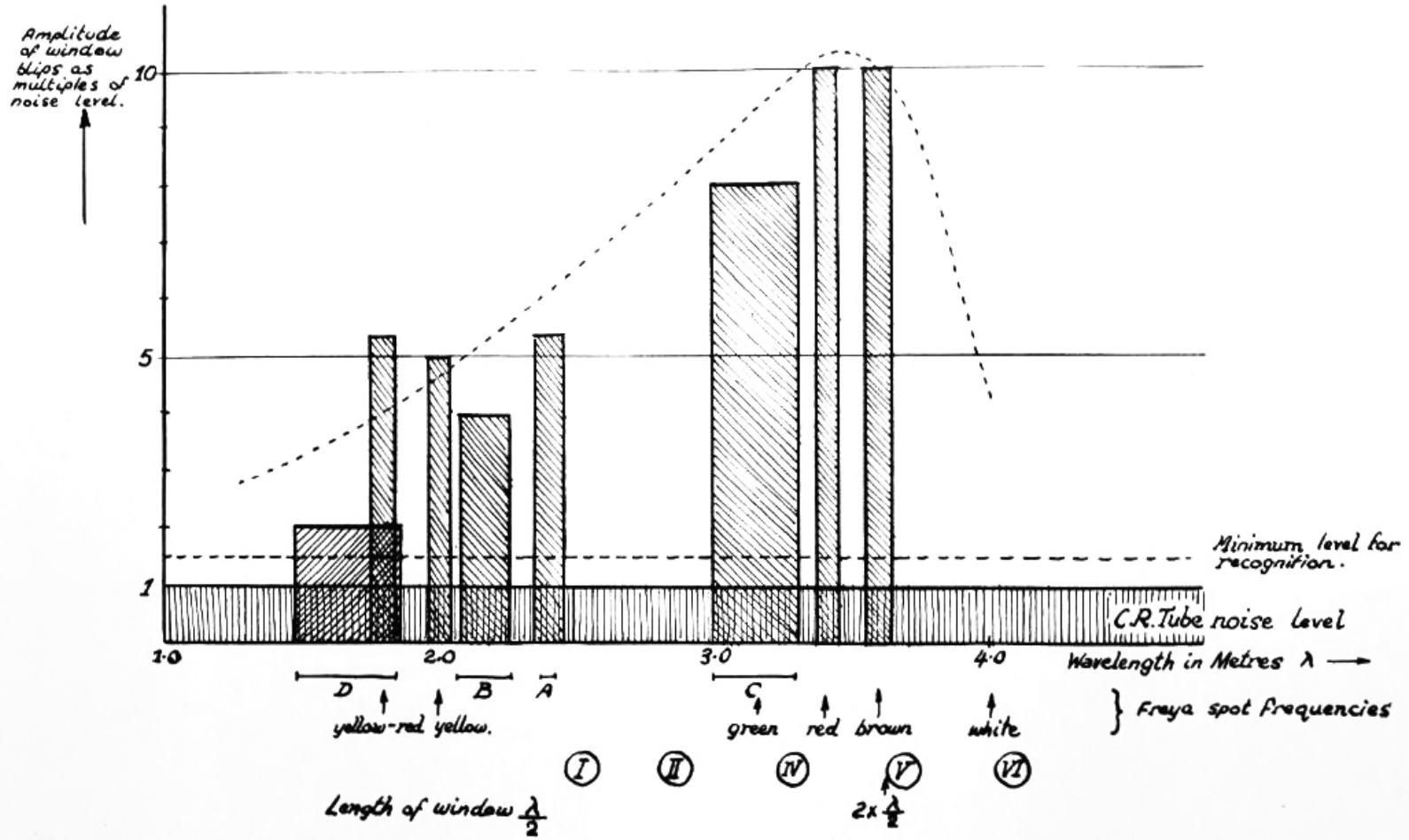
Forsthaus Z.

120. The Forsthaus Z was another form of 9 cm. panoramic for early warning, which was produced by the firm of Telefunken. It differed from Jagdschloss Z mainly in the design of aerials and was about in the same stage of production. No information

could be given as to the advantages or disadvantage possessed by Jagdschloss Z.

NOTE: One of the documents brought to England by General MARTINI’s staff contained a list of the frequency coverages mentioned in this report, and is reproduced in Appendix II.

"SPOOF-EFFECT" PRODUCED BY 1·80 METRE WINDOW



APPENDIX I

SECRET

WAVELENGTH COVERAGE OF RADAR EQUIPMENT

Würzburg			Freya		Jagdschloss	
Urechse	53,0-63,8	cm.	Wellen Insel	(A 2,32-2,45 m.	Gerät 1-62	1,20-1,90 m.
Insel A	53,0-54,2	cm.		(B 2,08-2,24 m.	Gerät ab 63	1,90-2,20 m.
Insel B	56,7-58,0	cm.		(C 3,00-3,30 m.	Gerät “lang”	8,00-10,00 m.
Insel C	62,3-63,8	cm.			Forsthaus F	25 cm.
G-Zusatz	2,20u.2,40	m.			Michael B	50 cm.
					Wassermann	
			Wellen Insel		M I	2,01-2,20 m.
					M II	1,90-2,50 m.
			Spot frequencies	(Z 1,50-1,55 m.	M III	1,20-1,90 m.
				(Y 1,55-1,60 m.	M IV	1,90-2,50 m.
				(X 1,60-1,65 m.	M V	2,50-4,00 m.
				(W 1,65-1,70 m.	L I	2,40 m.
				(V 1,70-1,75 m.	L II	2,01-2,27 m.
				(U 1,75-1,80 m.		Streuwellen mit
				(T 1,80-1,85 m.		1,5 MHz Abstand
			Köthen wellen	(Gelb/braun 1,70 m.	S 1-6 5 Gerät	2,46 m.
				(Gelb/rot 1,80 m.	2 Gerät	2,40 m.
				(Ludwig 1,95 m.	S 7-10 1 Gerät	2,36 m.
				(gelb 2,00 m.	1 Gerät	2,34 m.
				(gelb/grün 2,56 m.	1 Gerät	2,29 m.
				(grün 3,15 m.		
				(rot 3,40 m.		
				(braun 3,65 m.	See Elefant	
				(weiss 4,05 m.		
				(schwarz 4,60 m.	7,90-8,80 m.	
				(blau 4,80 m.	10,70-12,00 m;	
				(violett 5,20 m.		
				(grau 5,75 m.		
				(blau neu 8,80 m.		