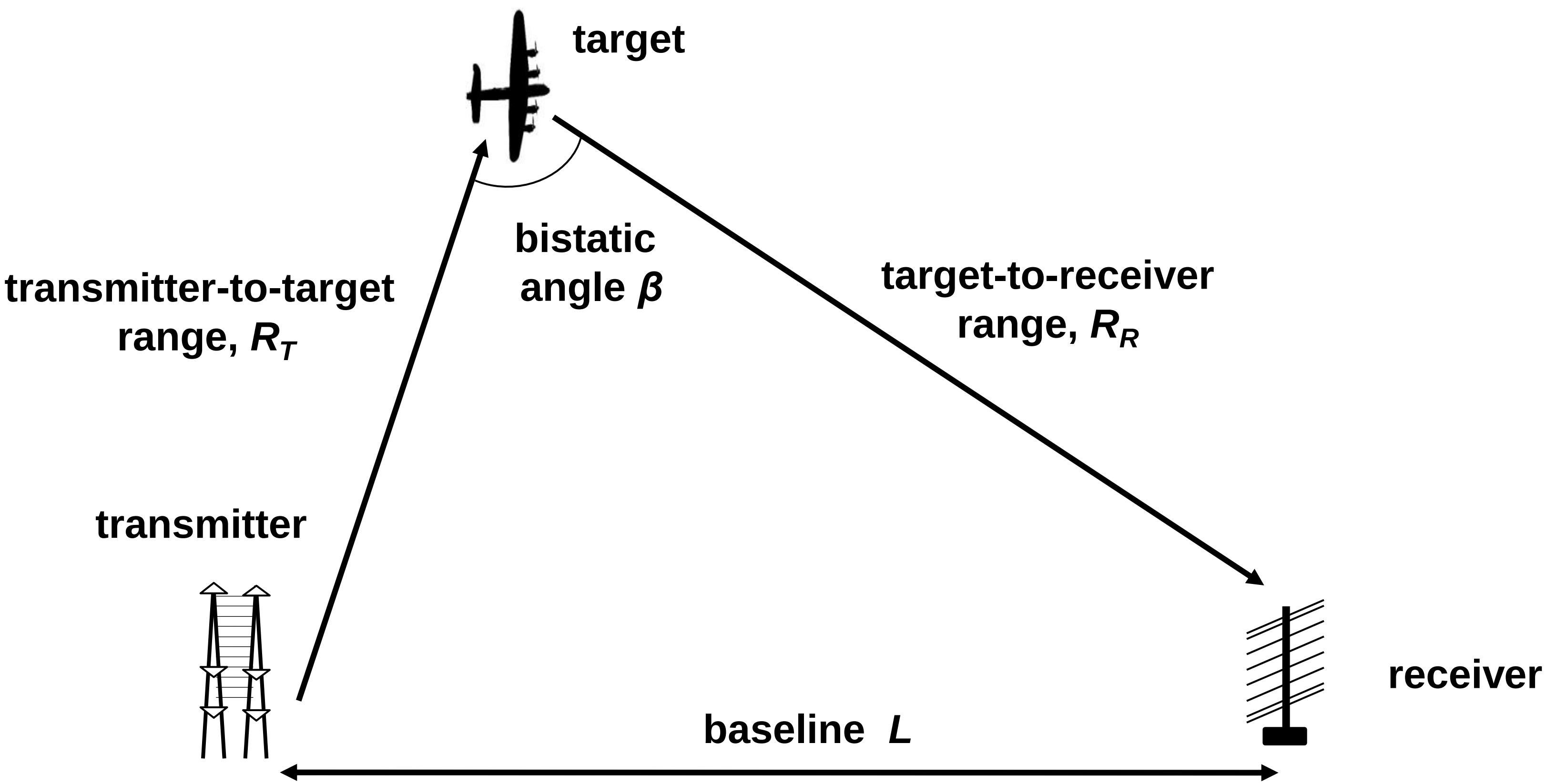
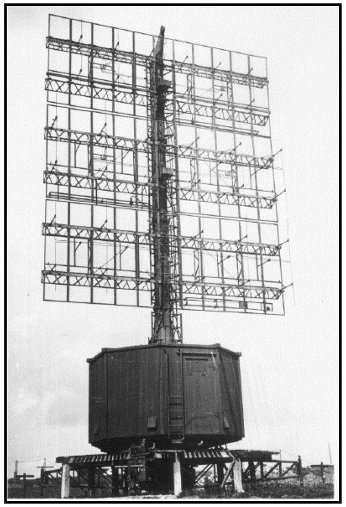
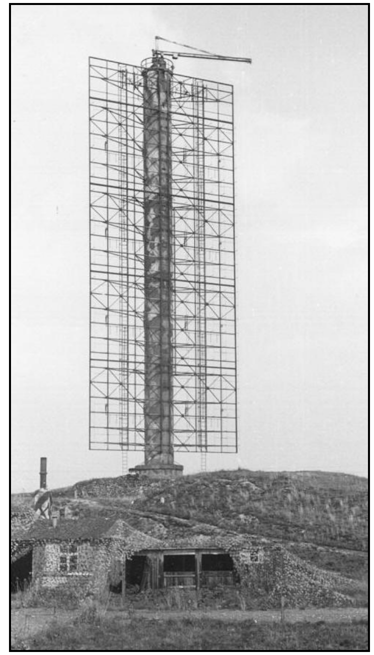
Bistatic radar

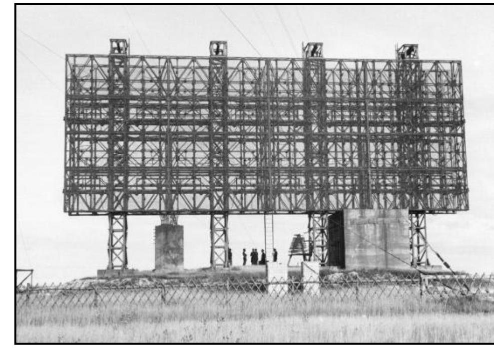


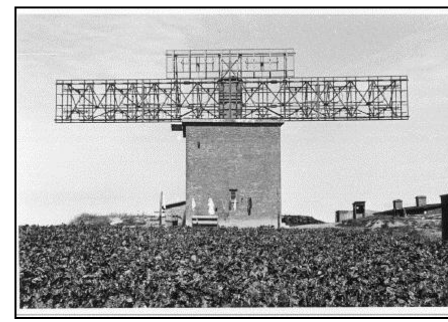
German WWII air defence radars

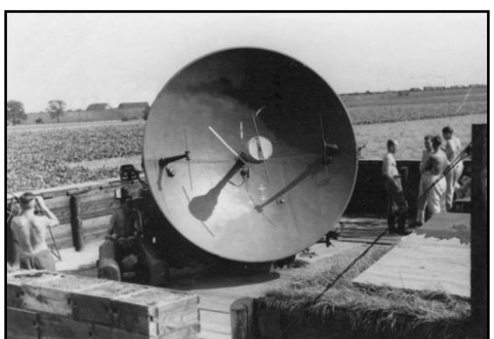
Freya, Wassermann, Mammut, Jagdschloss – early warning







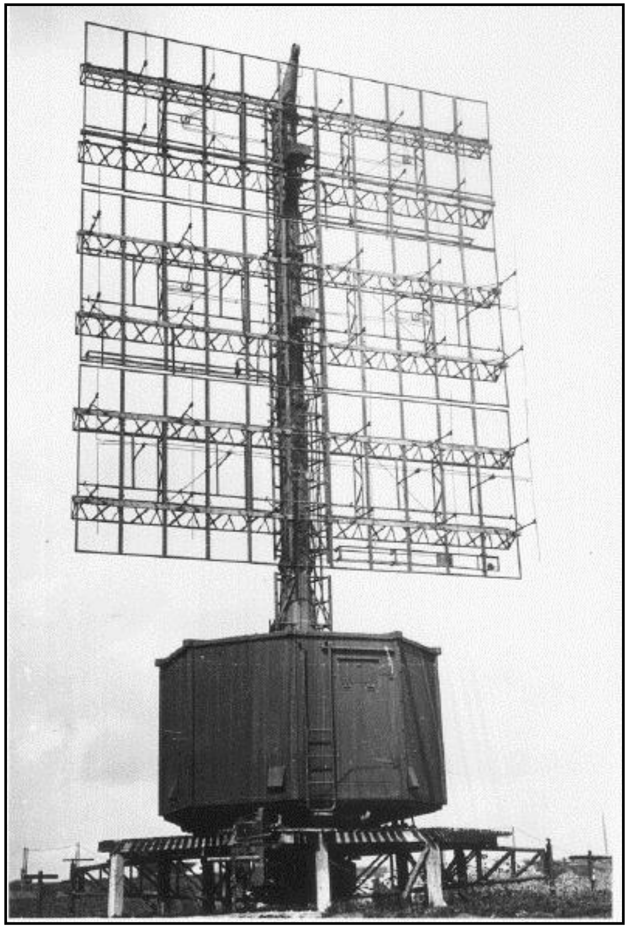




Würzburg – fighter control

Lichtenstein SN2 – AI

FREYA (FuMG 80, FuMG 401, ...)



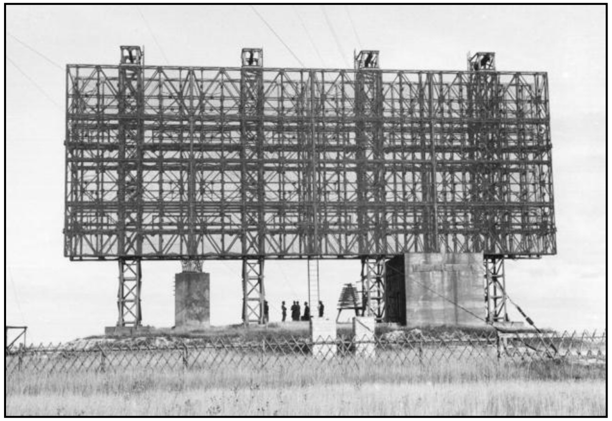
120 – 130 MHz band (λ = 2.5 – 2.3 m)
3 µs pulse
15 – 20 kW peak power
500 Hz PRF
6 m × 5 m antenna array, separate tx and rx
lobe-switching in horizontal plane

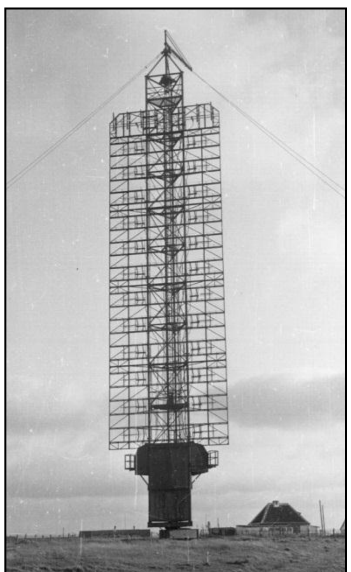
Named after the Norse goddess who had a necklace called *Brisingamen*, guarded by the watchman *Heimdall* who could see to the horizon in day or night. Understanding the origin of the name helped British scientists understand the function of FREYA.

FREYA radars were in service right from the beginning of the War, in various versions.

http://www.gyges.dk/

MAMMUT (FuMo 52), WASSERMANN (FuMG 402)





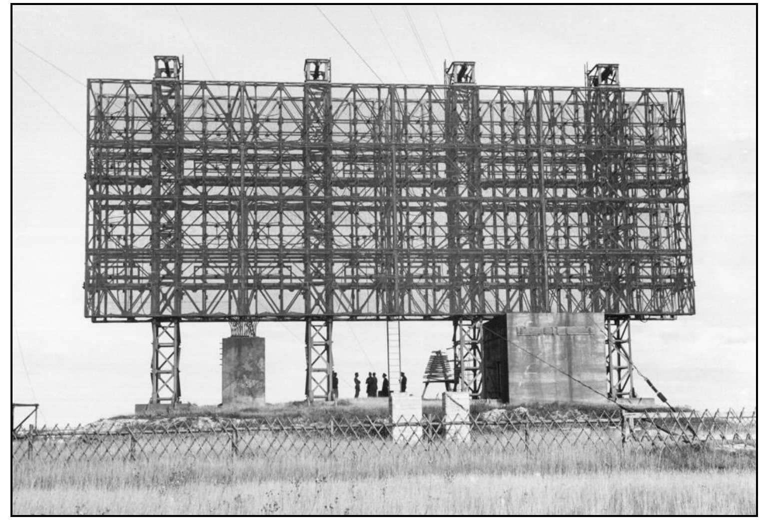
Subsequently MAMMUT (‘Hoarding’) and WASSERMANN (‘Chimney’) radars were developed from FREYA, using more or less the same basic hardware but higher-gain antennas, and with the first ones of both types going into service in 1942.

MAMMUT had essentially 16 FREYA antennas arranged in an array 30 m across × 10 m high with electrical beam steering over ±50° using helical lines as phase shifters, and 200 kW peak transmit power;

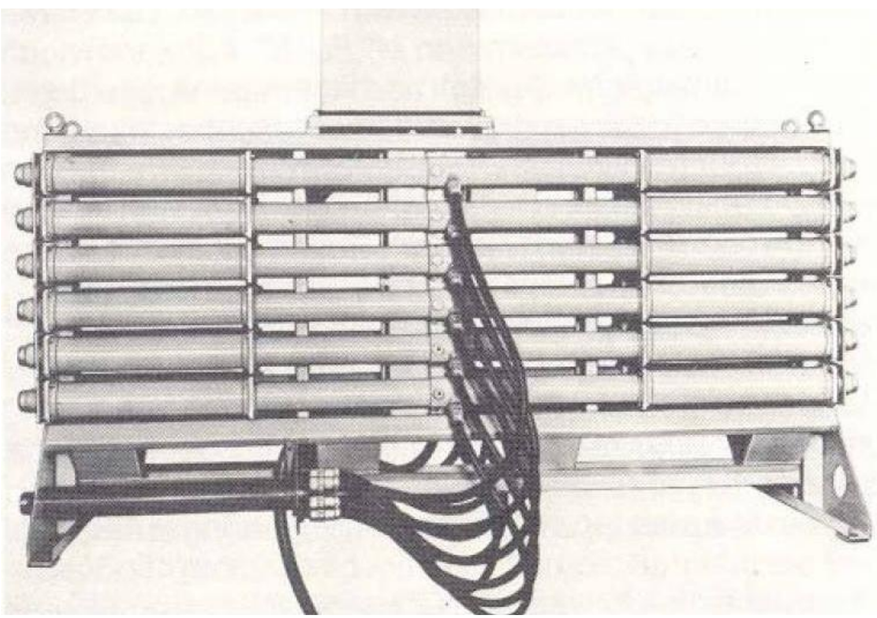
The WASSERMANN array of 8 or more FREYA antennas was 60 m high, 100 kW peak transmit power.

http://www.gyges.dk/

MAMMUT (FuMo 52)

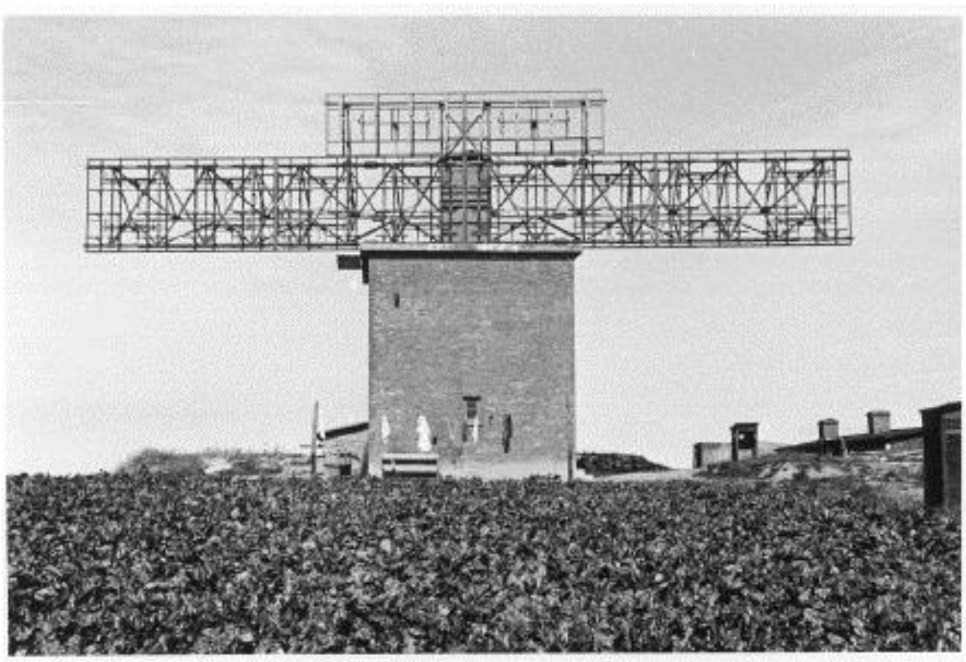


MAMMUT had essentially 16 FREYA antennas arranged in an array 30 m across × 10 m high with electrical beam steering over ±50° using helical lines as phase shifters, and 200 kW peak transmit power.



Picture of helical line phaseshifters in Trenkle’s book p97, also in *The Century of Radar* by Dr Wolfgang Holpp.

JAGDSCHLOSS (FuMG 404)

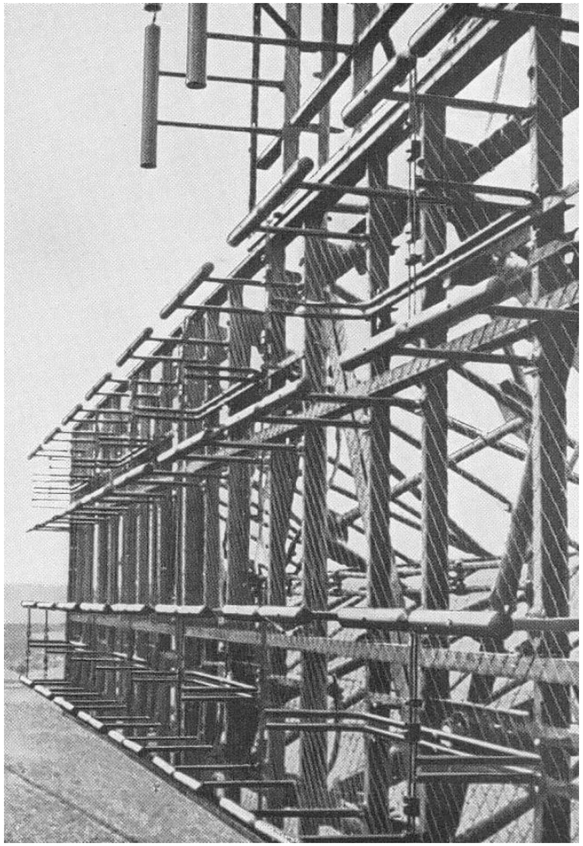


Another FREYA-derivative was JAGDSCHLOSS ('Hunting Lodge') which had a rotating antenna (at ~10 rpm) and a PPI display, as well as a slightly higher frequency. The PPI display information could be sent by land line or radio link (a scheme known as *Landbriefträger*).

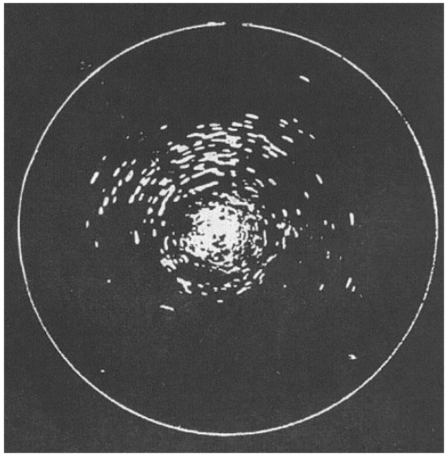
JAGDSCHLOSS began entering service towards the end of 1943. A total of 80 units were in service by the end of the war.

http://www.gyges.dk/

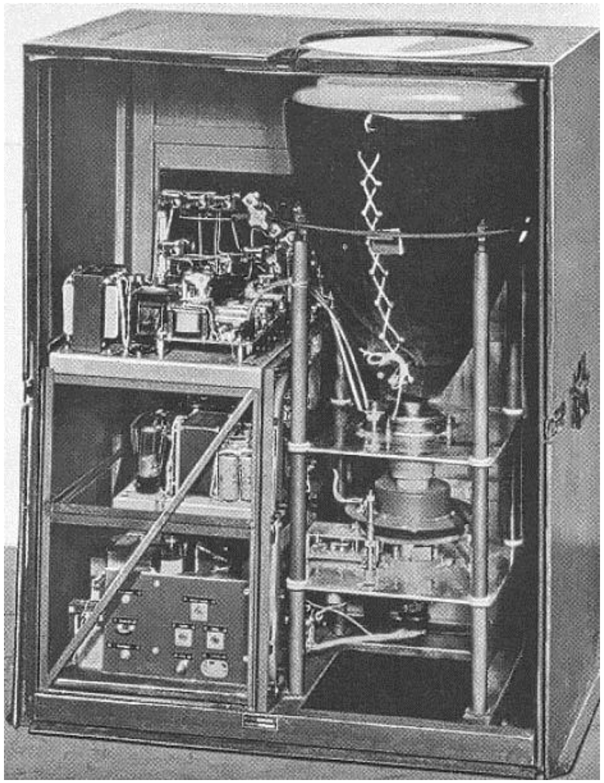
JAGDSCHLOSS (FuMG 404)



JAGDSCHLOSS array of horizontal dipoles. The upper, vertical dipoles are part of the IFF system.



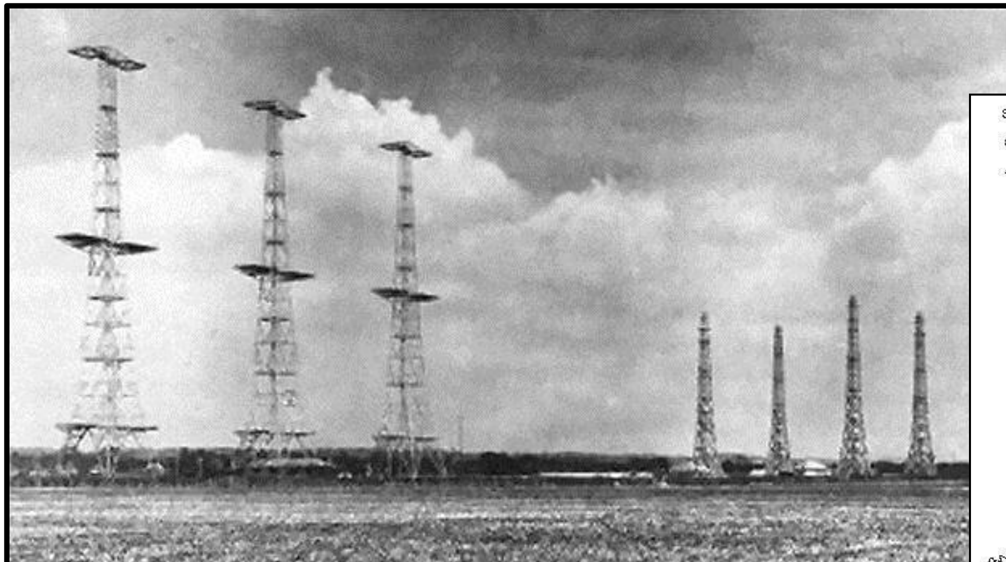
PPI display of raid over Berlin on 30 January 1944, showing ~ 400 aircraft. Range ring corresponds to 100 km.

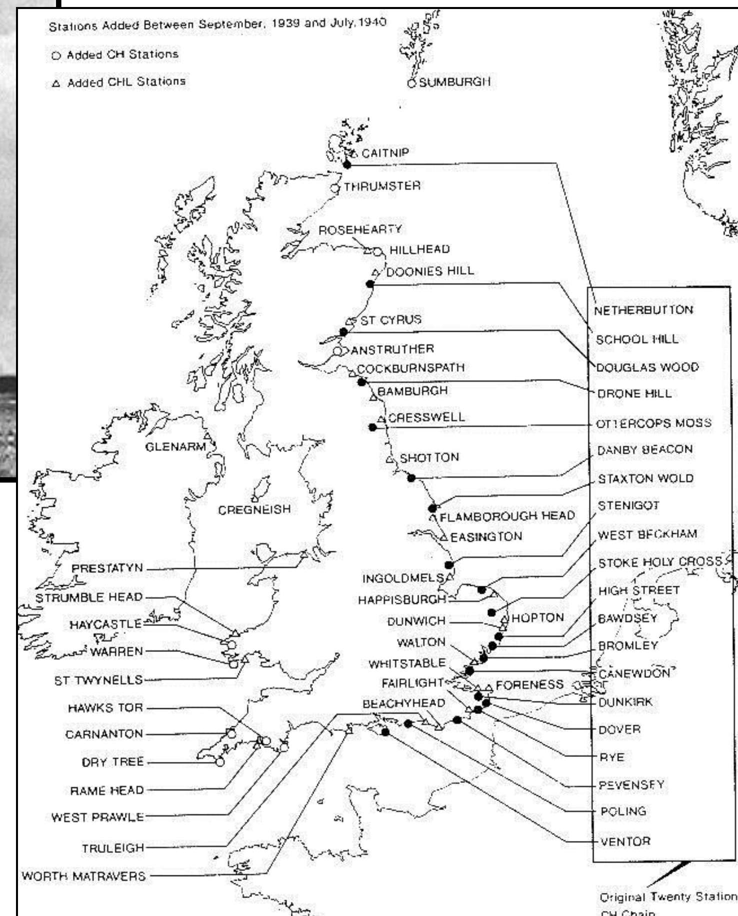


JAGDSCHLOSS CRT display. Diameter 40 cm

http://www.cdvandt.org/jagdschloss.htm

CHAIN HOME





Neale, B.T., ‘CH – the First Operational Radar’, *GEC Journal of Research*, Vol. 3 No.2 pp73-83, 1985.

CHAIN HOME

- The Chain Home radar has been described as a ‘dead-end design’, but as a *system* to deliver an air defence *capability* it was certainly very effective.

- There were four (later reduced to three) metal transmitter towers in a line, and four wooden receiver towers arranged in a rhomboid pattern. The transmitter produced floodlight illumination of approximately 100° beamwidth from a ‘curtain’ of eight horizontally-polarised half-wave dipoles, each with a tuned reflector element 0.18λ behind. The curtain included a main array above a secondary ‘gapfiller’ array of four dipoles. The stations could be tuned to four different bands in the range 20 MHz to 30 MHz. The operator could switch between the two arrays as needed. The output stage of the transmitters used special water-cooled tetrode valves built by Metropolitan Vickers.

- The wooden towers for the receiving arrays were shorter, about 76 m tall. Each wooden receiving tower initially featured three receiving antennas, in the form of two dipoles arranged in a cross configuration, spaced up the tower. Additional crossed dipoles would be fitted later in the War to deal with German jamming.

Greg Goebel, *The Wizard War: WW2 and the Origins of Radar*,

CHAIN HOME

- The direction of the echoes returning to the receiving towers could be determined by comparing the relative strengths of the echoes picked up by different crossed dipoles. by means of a Goniometer. Comparison of the receiving strength between crossed dipoles on different towers gave the horizontal angle to the target, while comparison of the receiving strength between the crossed dipoles arranged vertically on a tower gave the vertical angle. Only the two top dipoles on each tower were used to determine the horizontal direction, while all three were used to determine the vertical direction. The receiver design owed much to Watson-Watt's old lightning location system.

- The pulse width was very long by normal radar standards, ranging from 6 to 25 μs which meant a corresponding uncertainty in the range of a target. Even a 6 μs pulse gives a range resolution of only 1.8 km.

- Pulse power was high, with a peak power of 350 kW initially, then 800 kW, and ultimately1 MW.

Greg Goebel, *The Wizard War: WW2 and the Origins of Radar*, http://vectorsite.net/ttwiz.html

CHAIN HOME

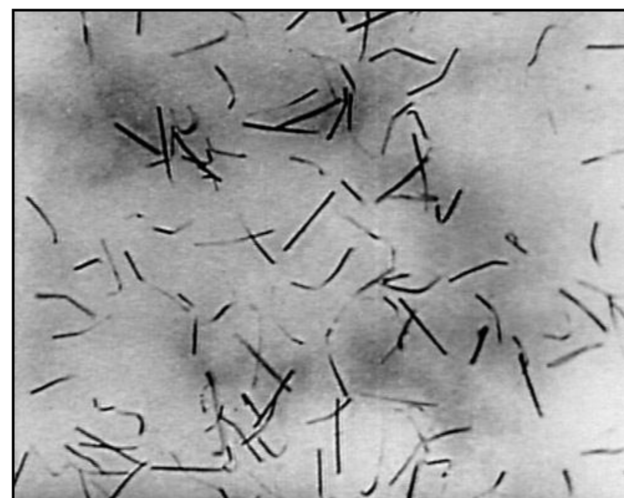
P.E. Judkins, *Making Vision into Power: Britain's Acquisition of the World's First Radar-based Integrated Air Defence System 1935 – 1941*, PhD thesis, DCMT

CHAFF (WINDOW)

Developed independently by the British and Germans (*Düppel*).

Churchill did not allow the use of Window until the bombing raids on Hamburg, 23 July 1943 – OPERATION GOMORRAH.

The term ‘window’ was originated by Albert (A.P.) Rowe, Superintendent of TRE at the time (late 1941, early 1942), in discussion with Dr Robert Cockburn. Much of the research had been conducted by Joan Curran, who was the only female scientist at TRE at the time.



It was necessary to have a codeword, and it was felt that it should bear no relationship to the device itself. Rowe looked around the room and said: ‘What about ‘window’ ? So *window* it was.

MANDREL

- MANDREL was a low-power (~2W) noise barrage jammer against FREYA and its derivatives, introduced early in December 1942, and carried either by Stirling bombers of 199 Squadron (self-screening) or by Defiant aircraft of 515 Squadron (stand-off).

- When MANDREL was introduced, Bomber Command losses (expressed in losses per 1,000 sorties) fell significantly. In response the Germans widened the band over which FREYA could operate, first to 120 – 140 MHz then to 120 – 160 MHz, and ultimately even wider than that, and the frequency coverage of MANDREL had to be increased accordingly.

- Also, automatic on-off switching of MANDREL was incorporated to attempt to prevent the enemy homing on the jammer signal.

- MANDREL SCREEN was a more sophisticated implementation of MANDREL, introduced in June 1944 (171 and 199 Squadrons), with pairs of jamming aircraft working together to give full coverage of the band, which by then had widened considerably.

Countermeasures

ASPIRIN : jammer for KNICKEBEIN
BROMIDE : jammer for X-GERÄT
SHIVER : jammer for the 24–26 MHz IF of WURZBURG
MANDREL : airborne noise jammer for FREYA-type radars
CARPET : jammer for WURZBURG fighter control radar 300–600 MHz
GROCER : jammer for LICHTENSTEIN AI radar
BOOZER : warning receiver for AI radar
TINSEL : jammer for 3–6 MHz ground-to-air R/T
CIGAR : jammer for 38–42 MHz VHF comms
ABC : AirBorne CIGAR
CORONA : false instructions for R/T control of night fighters 2.5–6 MHz
DARTBOARD : jammer for MF broadcast signals
DRUMSTICK : jammer for HF W/T 3–6 MHz
BULLSEYE : feint using training aircraft
FIDGET : jammer for MF and sometimes HF W/T
JOSTLE : high-power FM CW jamming of R/T over bands from 3–54 MHz
PIPERACK : jammer for enemy radar, 95–210 MHz
MONICA : tail warning radar
PERFECTOS : detector carried by Mosquitoes for German IFF transmissions

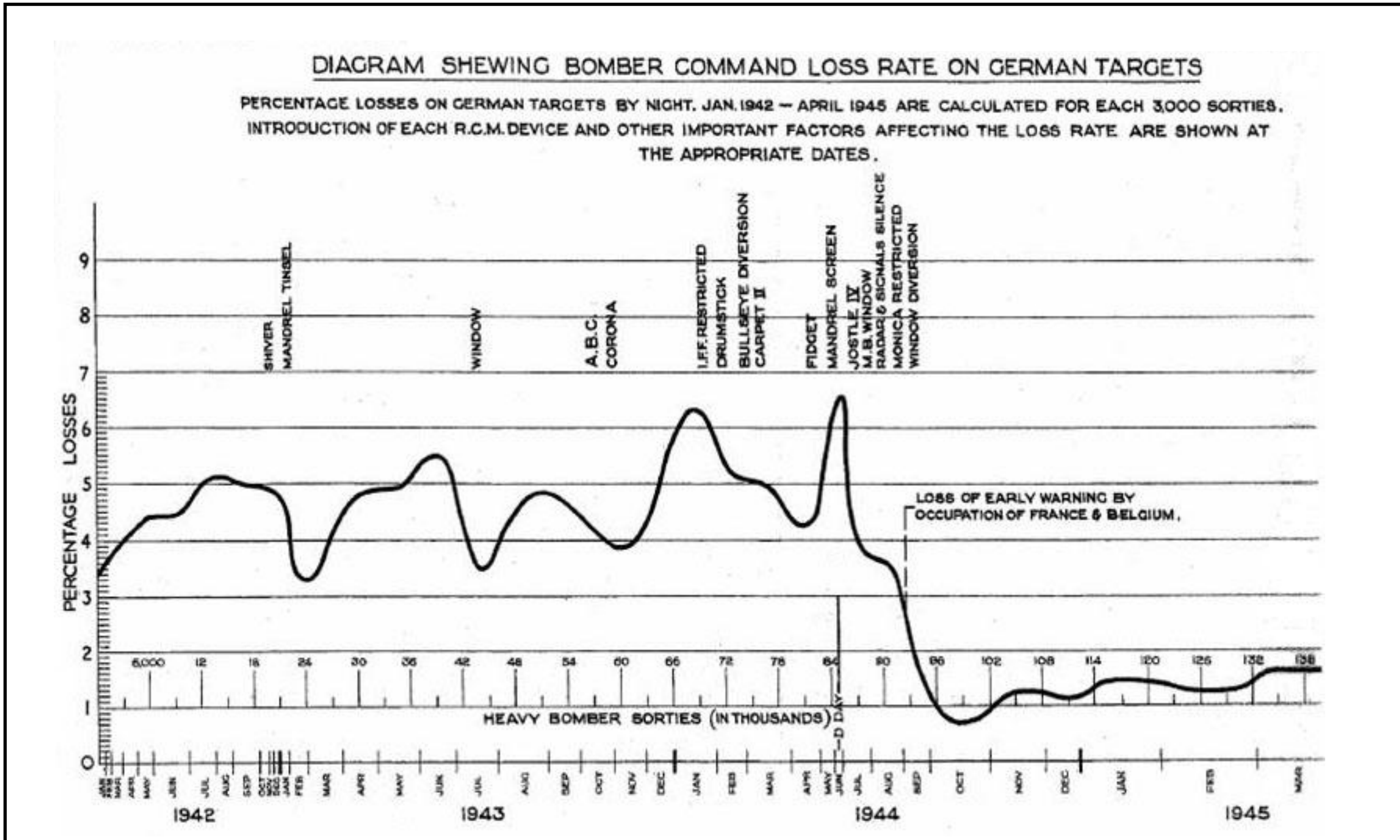
War in the Æther: Radio Countermeasures in Bomber Command – an Historical Note, Signals Branch, Headquarters Bomber Command, 621.391.825 H, October 1945.

Countermeasures

FLAMMEN : receiver to allow homing on IFF transmissions
ERSTLING : IFF system using FREYA transmissions
ZWILLING : IFF system using WURZBURG transmissions
NAXOS : warning receiver and homing device for H2S transmissions
KORFU : more sophisticated warning receiver for H2S transmissions
FLENSBURG : receiver to allow homing on MONICA transmissions
WURZLAUS : device to distinguish aircraft from chaff using Doppler effect.
also FREYA-LAUS, WASSERFLOH
FREYA-FLAMME : device to trigger Allied IFF
FREYA-HALBE : receiver to detect and home on jamming aircraft against FREYA
NÜRNBERG : scheme to distinguish aircraft from chaff using engine vibrations
TAUNUS : scheme to distinguish aircraft from chaff using persistence
KETTENHUND : jammer for EUREKA
METOX : warning receiver carried by U-boats
SPANNER : airborne infra-red search systems – passive and active
BERNHARD / BERNHARDINE : secure ground-to-air communications

History of the German Night Fighter Force 1917–1945, Gebhard Aders, Jane's, 1978

Klein Heidelberg



War in the Æther: Radio Countermeasures in Bomber Command – an Historical Note, Signals Branch, Headquarters Bomber Command, 621.391.825 H, October 1945.

Exercise POST MORTEM

- An exercise carried out immediately after the end of WWII in Europe (8 May 1945), against the German air defence system in Schleswig-Holstein and Denmark, which had been captured intact.

- It was conducted scientifically, using first of all a bomber raid with no countermeasures as a reference against which to compare the others which used different permutations of raid profile and countermeasures. The defences (*Y-Dienst*, observer corps and radar, but not fighter aircraft) were operated by German personnel.

- Fourteen exercises were planned, of which only eleven were flown, during 9 days between 25 June and 5 July. Three were cancelled due to bad weather.

- It showed that the effectiveness of MANDREL, and of Radio Countermeasures (RCM) in general, were by no means total.

Report on an Investigation of a Portion of the German Raid Reporting and Control System (Exercise Post Mortem), Air Ministry, 18 June 1945.

Judkins, P., *Did Radio Countermeasures in WW2 Really Work?* DEHS Symposium podcast, Shrivenham, 13 February 2007.

POST MORTEM

Raid 1: Reference raid – no Window, no jamming, but H2S throughout, high profile, 216 4-engined heavy bombers 17,000 – 20,000 ft. Raid detected at 120 miles, and accurately identified. One bomber kept IFF on, and was tracked throughout. Y-service detected H2S throughout.

Raid 2: To test advantage of low-level approach – 228 aircraft 2,000 – 3,000 ft till 90 miles from coast, then 17,000 – 20,000 ft. No Window, H2S from 35 miles out. Once acquired, aircraft tracked accurately. Low approach reduced detection range by about 1/3.

Raid 3: To test effectiveness of Window. High profile throughout, no jammers, but Window. Successful, but Y-service detected H2S and IFF from over 200 km, and plotted accurately throughout. See-Elefant unaffected. But controller discounted Y-service information.

Raid 4: Same route as 3, 194 aircraft at 18,000 ft, but with Mandrel screen in front, and Window. But not able to give full band coverage. See-Elefant and Wurzburg completely unaffected. Y-service plotted accurately throughout.

Raid 5: Full weight of RCM – Mandrel, feint using Window, comms jamming, most radars affected for some of the time. But sufficient radars worked for enough of the time, and Y-service all of the time. See-Elefant unaffected despite attempts to jam. Y-service intercepted IFF and H2S from 185 km from coast.

Raid 6: Window spoof, no jamming, 23 aircraft at 18,000 ft. Longest range Y-service interception at 448 km from coast. Controller initially accurately identified number of aircraft, but later changed his mind.

Raid 8: All out raid, full panoply of RCM. All radars except See-Elefant reported severe jamming. But Y-service plotted accurately throughout.

Raid 9: Window screen, most radars affected, but Controller identified from 190 km out.

Raid 10: Everything in the kitchen sink, jamming, 2 Window feints in different directions – but success of RCM not total. Good, but perhaps a little disappointing.

Raid 11: Mosquitoes (high-speed) at high level > 25,000 ft, no countermeasures – 200 km warning.

Raid 12: Mosquitoes at low level, 114 km best detection range, most radars at 50 – 80 km.

CHAIN HOME

‘The Germans would not have been surprised to hear our radar pulses, for they had developed a technically efficient radar system which was in some respects ahead of our own. What would have surprised them, however, was the extent to which we had turned our discoveries to practical effect, and woven all into our general air defence system. In this we led the world, and it was operational efficiency rather than novelty of equipment that was the British achievement’

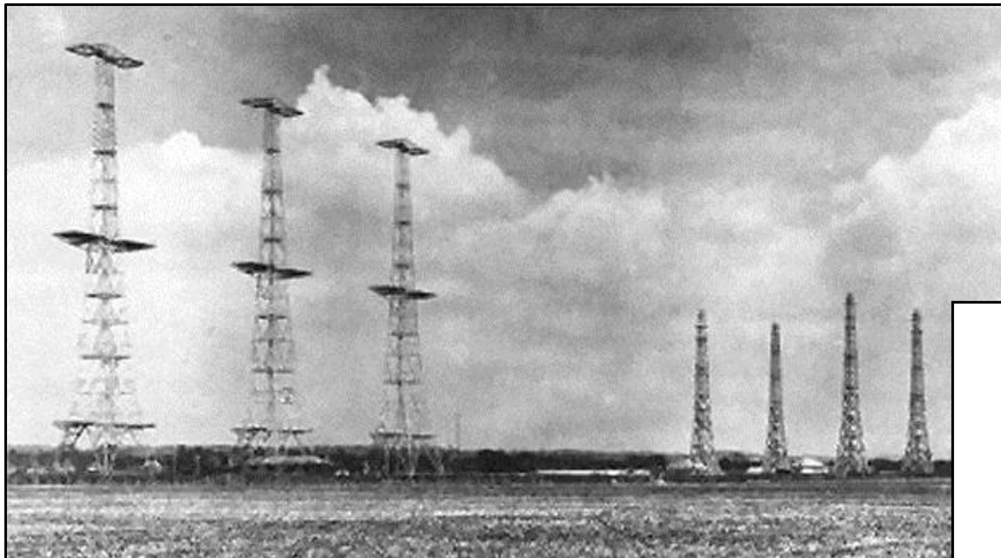
Winston S. Churchill: *The Gathering Storm*, Cassel, p122, 1948.

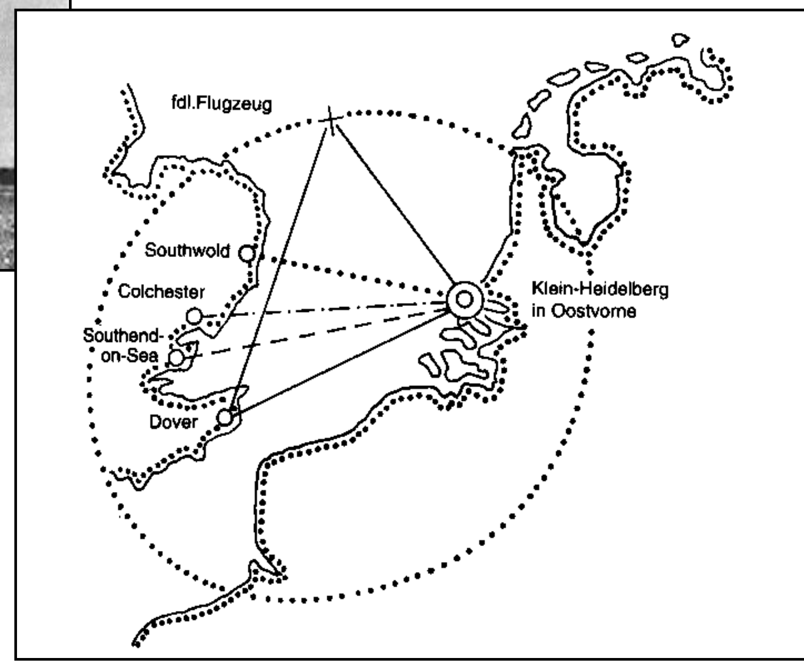
‘The British had, from the first, an extraordinary advantage, never to be balanced out at any time in the whole war: their radar and fighter-control network. It was for us and our leadership a freely expressed surprise, and at that a very bitter one, that Britain had at its disposal a close-meshed system, obviously carried to the highest level of current technique, which supplied the British Fighter Command with the most complete basis for direction imaginable … We had nothing like it …‘

General Adolf Galland, in E.G. Bowen: *Radar Days*, Hillger, p28, 1987.

Quoted at the beginning of *Making Vision into Power: Britain's Acquisition of the World's First Radar-based Integrated Air Defence System 1935 – 1941*, P.E. Judkins, PhD thesis, DCMT Shrivenham, 2007.

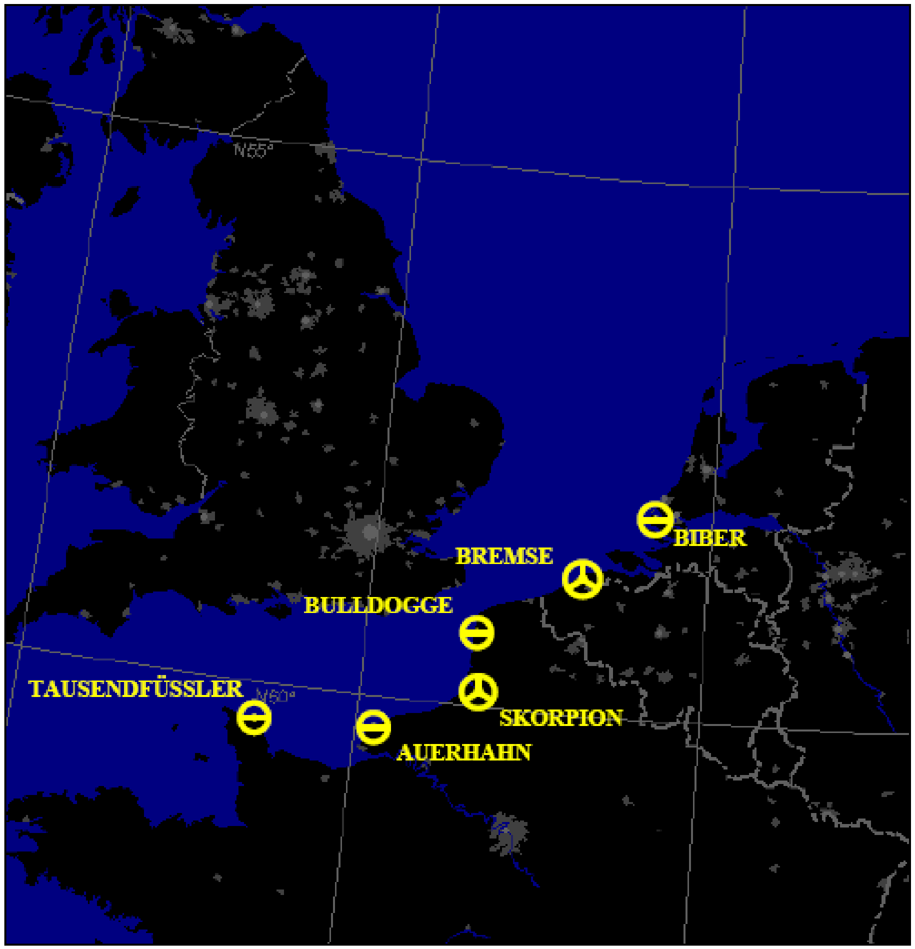
Klein Heidelberg





Karl-Otto Hoffmann, *Ln-Die Geschichte der Luftnachrichtentruppe, Band I/II*, Kurt Vowinckel Verlag, Neckargemünd, 1965.

Klein Heidelberg *Stellungen*



There were six KH *Stellungen* (sites):

BIBER (Oostvoorne)
BREMSE (Ostend)
BULLDOGGE (Boulogne)
SKORPION (Vaudricourt, Abbeville)
AUERHAHN (Cap d'Antifer)
TAUSENDFÜSSLER (Cherbourg)

Some sources also include Castricum (Netherlands) and Rømø (Denmark), but these were ELEFANT and SEE-ELEFANT/RÜSSEL radars, whose receive antennas were similar to those of KH.

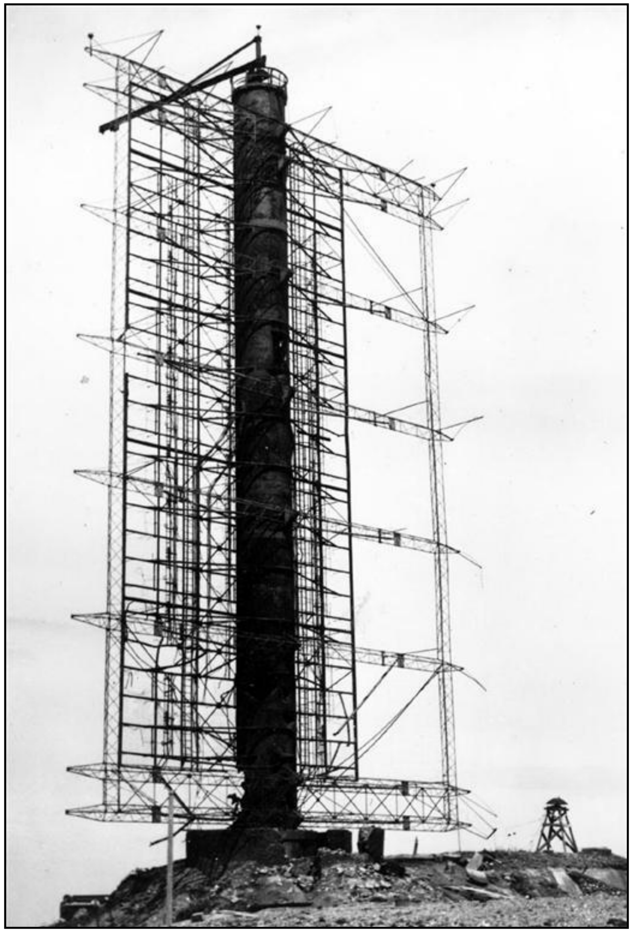
SEE-ELEFANT/RÜSSEL had a KH-type mode, but it is not clear how well it would have worked.

 1st order *Stellungen*

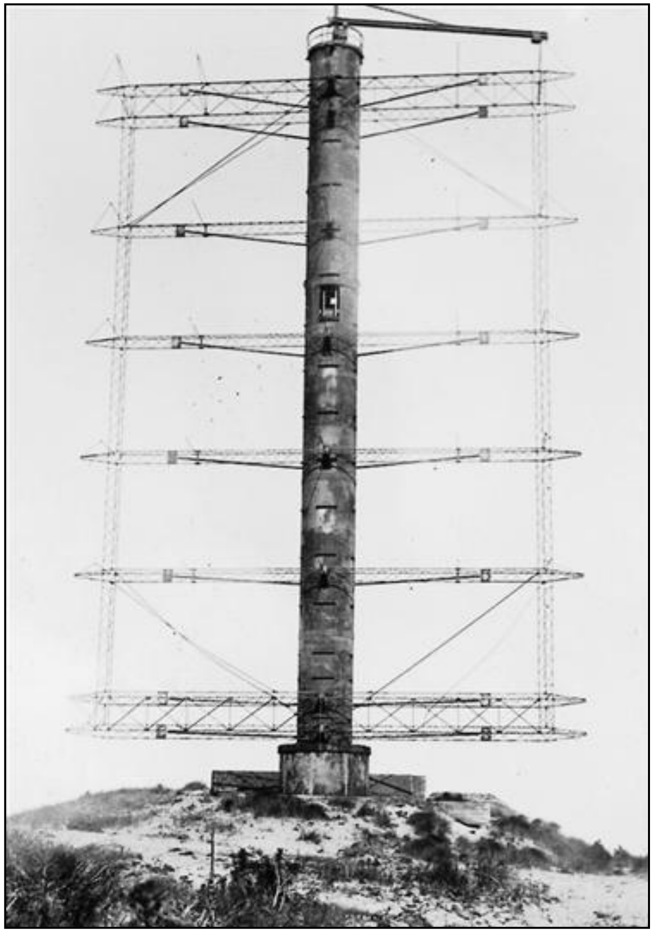
 2nd order *Stellungen*

http://www.gyges.dk/Klein%20Heidelberg.htm

Klein Heidelberg

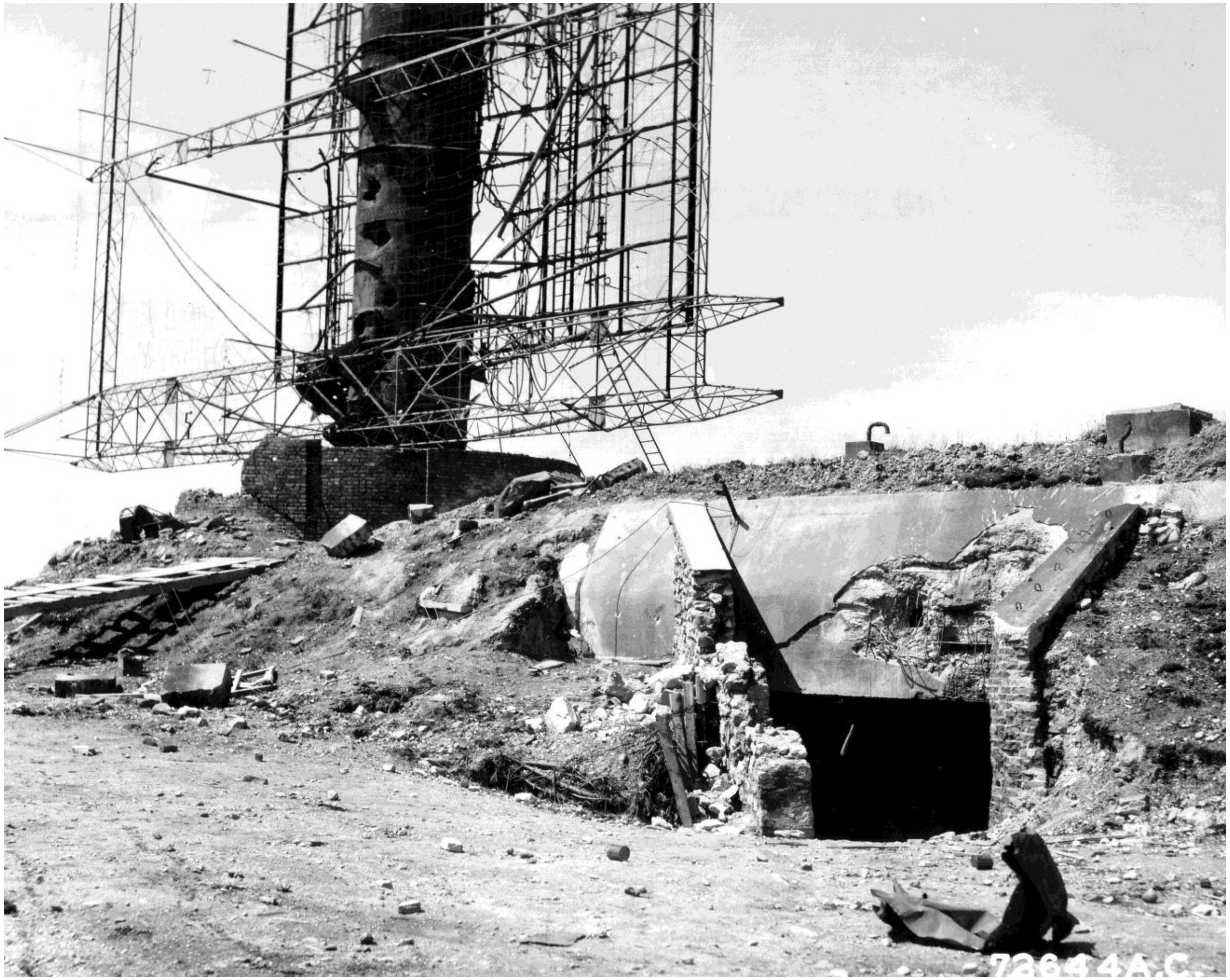


Stellung TAUSENDFÜSSLER
(Cherbourg)



Stellung BIBER
(Netherlands)

Klein Heidelberg



Stellung TAUSENDFUESSLER (Cherbourg)

Conseil Régional de Basse-Normandie / National Archives

Klein Heidelberg

picture © Jeroen Rijpsma

TOP SECRET

AIR SCIENTIFIC INTELLIGENCE

INTERIM REPORT

HEIDELBERG

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INTRODUCTION

1.1. The enemy has been attempting to use the radiations from our own CH stations to plot our aircraft through the Mandrel screen. The evidence from the various sources is reviewed and possible countermeasures are considered.

INTELLIGENCE

2.1. A.D.I.(K) has provided the only direct evidence; this comes from the interrogation of a prisoner, previously a Wassermann operator, who was posted last May to the Wassermann site at Abbeville / Vaudricourt. According to his story the apparatus was equipped with a receiver, but no transmitter. Plots were obtained by locking on to the pulses from the Dover CH station. The maximum range claimed each day was usually about 450 Km; the range accuracy was said to be ± 10 Km.

2.2. The method is simple. The reading on the range tube gives the difference between (i) the distance from the CH to the Wassermann and (ii) the length of the path CH - aircraft - Wassermann. Since (i) is fixed and known, this determines (ii). Hence the aircraft must lie on an ellipse whose foci are the CH and the Wassermann. The position of the aircraft on the ellipse is then determined by taking a bearing. The prisoner declared that the Wassermann also gave the height of the aircraft.

2.3. The prisoner referred to the presentation unit of the Wassermann as "Heidelberg".

2.4. The Wassermann at Vaudricourt is known from photographic evidence to have a wider array than normal. This has only been seen on seven apparatuses, some of which carry the normal array as well. They are listed below.

Limmen / Duinont	52° 35' 02" N	04° 37' 22" E
Oostvoorne / Zeehonden	51° 54' 16" N	04° 03' 30" E
Ostend / de Hahn	51° 16' 49" N	03° 02' 56" E
Boulogne Monument	50° 44' 46" N	01° 36' 52" E
Abbeville / Vaudricourt	50° 07' 00" N	01° 32' 00" E
Cap d'Antifer	49° 40' 24" N	00° 09' 45" E
Cherbourg / La Brasserie	49° 40' 05" N	01° 28' 10" W

The Boulogne Wassermann had the large array by about August 1943. The remainder were not completed until towards the end of the year.

2.5. The German Air Signals Experimental Regiment is known to have a detachment at Oostvoorne. They refer in their correspondence to an apparatus called Klein Heidelberg. Since we know that there is a Wassermann at Oostvoorne similar to that at Vaudricourt, we may reasonably suppose that they are for the same purpose. The relation between Heidelberg and Klein Heidelberg is not known, but it is assumed to be close.

2.6. A further detachment of the Air Signals Experimental Regiment is known to have arrived at Oostvoorne in December 1943 from Boulogne. Oostvoorne was not operational at that time but it was expected to be so shortly. It looks therefore, as if the Boulogne site was operational during the later part of 1943 and that experienced personnel from there had been sent to start up the Oostvoorne site.

2.7. We have no further information concerning the remaining sites.

2.8. Captured documents dated November 1942 have referred to "Heidelberg" being under development.

VALUE TO THE ENEMY

3.1. From the above evidence it seems clear that the enemy has used the method, if only on a small scale. During the first half of this year he was getting from his radar, and latterly from his route-tracking organisations, an abundance of information which would have observed any additional long range plots obtained by the Heidelberg method. The present situation is something of a mystery however. For the last few months his main trouble in deploying his night fighters has been lack of early warning owing to the Mandrel Screen and to radio silence on the part of the bomber force.

3.2. It is inconceivable that the enemy would neglect any available method of obtaining early warning. Hence he must have encountered some difficulty, of whose nature we are unaware, in using this system, at least on the Dutch stations. While the present picture is not clear, the method represents a threat to our bomber offensive which we cannot neglect.

OTHER SUITABLE TRANSMISSIONS

4.1. In order to be fairly sure of getting a plot over any desired area by this method it is only necessary that the transmitter concerned be of reasonably high power and wide angle, and emit suitably sharp pulses. Apart from the CH's themselves, the CH stand-by sets (42-50 Mc/s) and the Gee transmitters are the most suitable. Although there is as yet no evidence that the enemy is using the latter transmissions, we should bear the possibility in mind.

POSSIBLE COUNTERMEASURES

5.1. Provided that we can be reasonably sure of identifying the responsible apparatuses a simple countermeasure would be to destroy them. The main difficulty is that, while we can be reasonably sure of identifying Chimneys on the coast, we cannot be sure of finding them inland, nor of finding other types of apparatus which might be used.

5.2. It has been proposed as a countermeasure to put two CH stations on the same frequency and "jitter" their pulses. This would not be satisfactory because (i) the enemy could employ a directional aerial, and so select whichever station he preferred, and (ii) even if he did not do this but merely

triggered his time base at every direct pulse, he would only develop an ambiguity, which could probably be resolved by a few minutes' plotting, and which would in any case give him the early warning he so badly wants.

5.3. With the CH stations and their stand-by stations two better radio-countermeasures suggest themselves. The first and obvious one is to switch them off as the Mandrel Screen comes on. A second and rather nicer one is to fit a "Moonshine" modification so as to provide the enemy with false plots. It would be possible in this way to decide whether or not the enemy is at present using the method; we could easily simulate a force of bombers flying across the North Sea and observe the enemy's reactions. If successful the device could be used to provide so many false alarms that he could no longer trust the observations.

5.4. Should he decide to use Gee transmissions, radio-countermeasures might be difficult without interfering with our own use of this aid. In this case destruction of the receiving apparatuses responsible may be the best alternative.

24.11.44. A.D.I.(Science).

Klein Heidelberg

CH monostatic radar:

$$P_R = \frac{P_T G_T G_R \lambda^2 \sigma_M}{(4\pi)^3 R_M^4}$$

R_M = 330 km for a medium bomber
at 20 – 25 kft

KH bistatic receiver:

$$P_R = \frac{P_T G_T(\theta) G_{KH} \lambda^2 \sigma_B}{(4\pi)^3 R_T^2 R_R^2}$$

If we assume the two receivers are equally sensitive, then a plot of

$$\frac{G_T(\theta)}{G_T} \cdot \frac{G_{KH}}{G_R} \cdot \frac{\sigma_B}{\sigma_M} \cdot \frac{R_M^4}{R_T^2 R_R^2}$$

shows the detection performance of KH, with respect to the MDS of CH.

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$$\frac{G_T(\theta)}{G_T} \cdot \frac{G_{KH}}{G_R} \cdot \frac{\sigma_B}{\sigma_M} \cdot \frac{R_M^4}{R_T^2 R_R^2}$$

Tx pattern of CH, normalised to 1 at its peak

perhaps 3 – 5 dB

1 to first order, except in forward scatter

R_M ~ 180 nmi (330 km) for a medium bomber at 20 -25 kft

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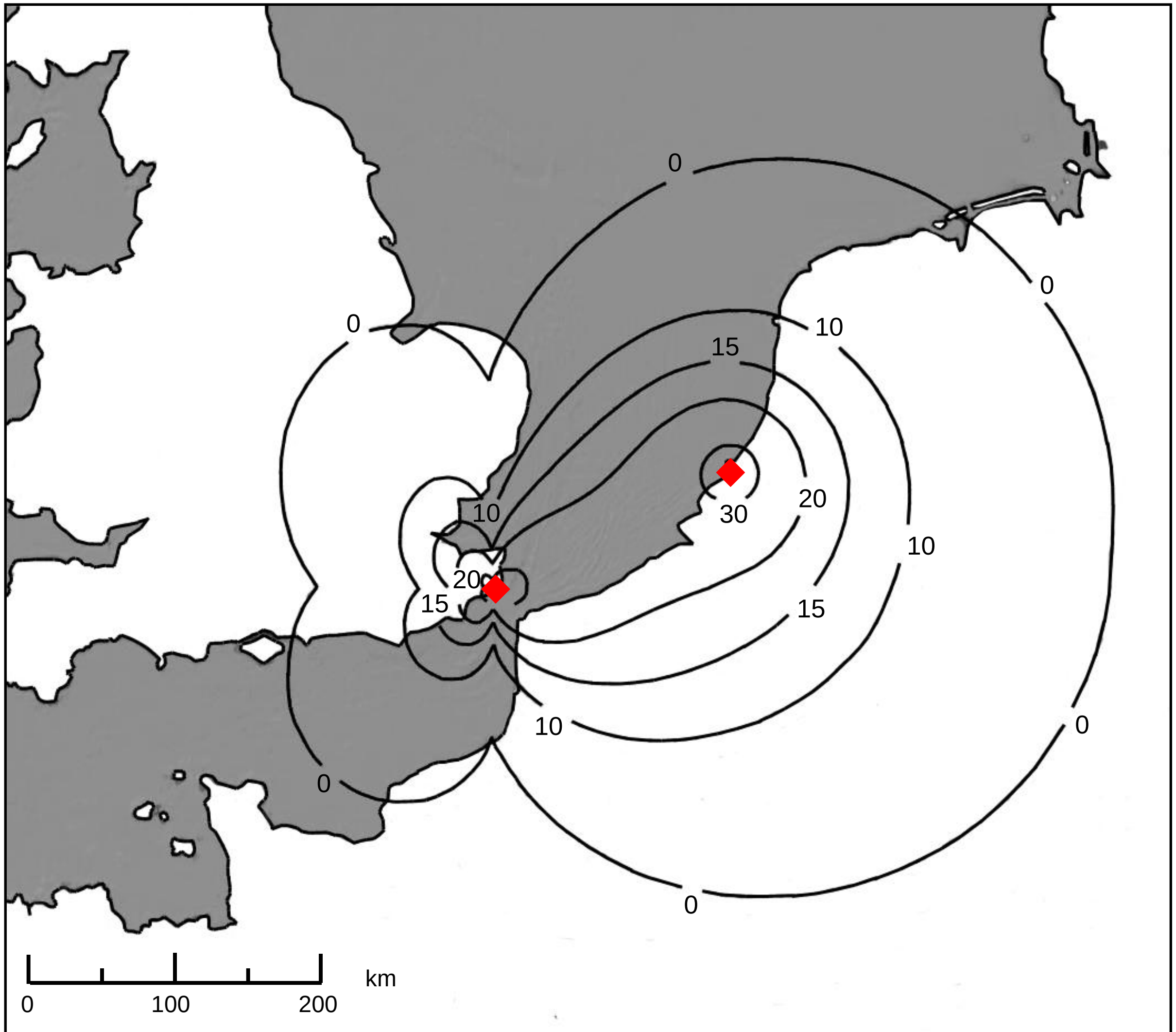
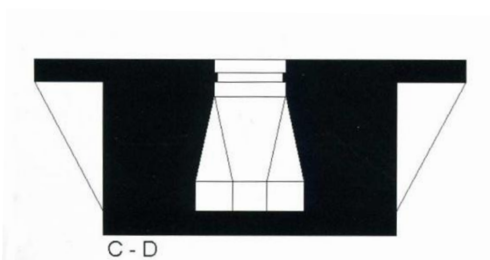
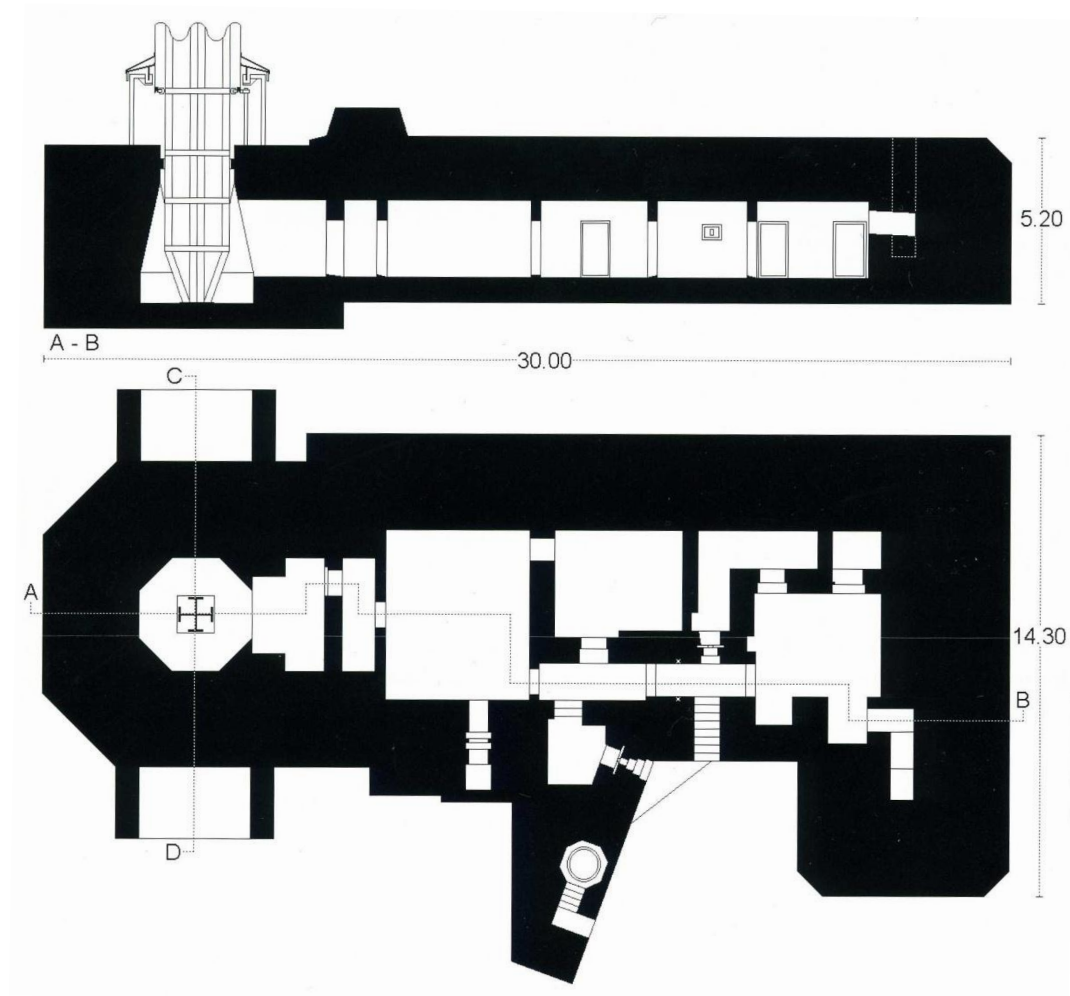


Comparative detection performance of the KH at Oostvoorne using the CH transmitter at Dover, against a medium bomber target.

Plot: James Brown, UCL

Klein Heidelberg: L480 bunker





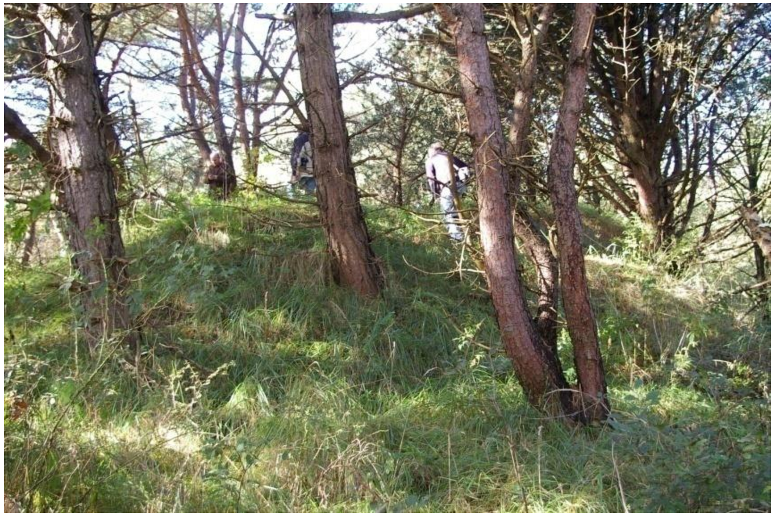
L-480 Bunker (*Stellung* BIBER)

Radarstellung BIBER: Kustverdediging op Voorne 1940 – 1945, Jeroen Rijpsma and Klaas van Brakel, 2005


X
X
X
X
X
X
200 ft
50 m
©2009 Google - Imagery ©

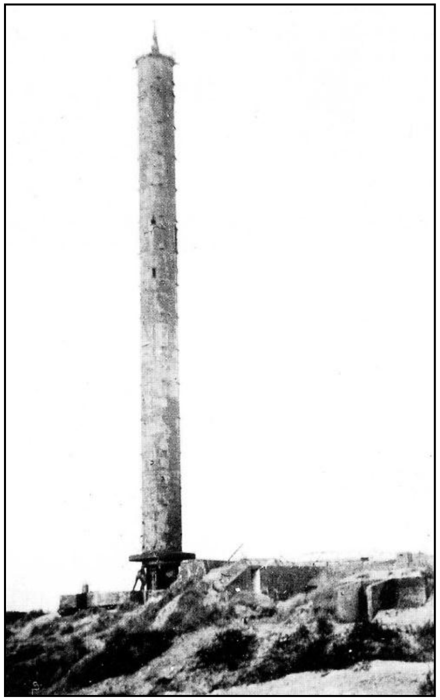

Percier Fontaine
94
94

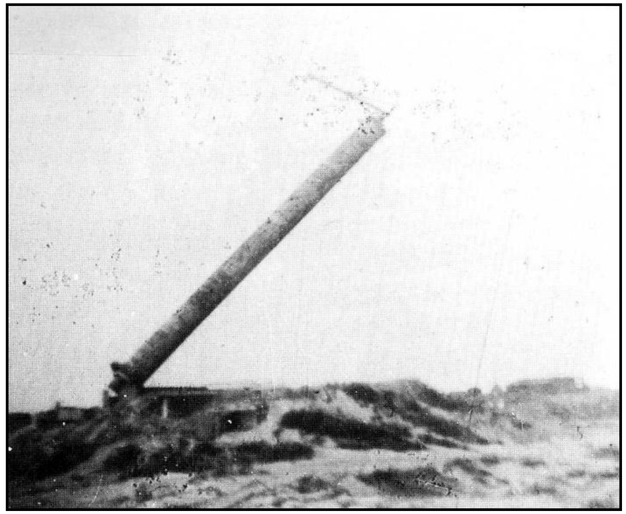
Klein Heidelberg

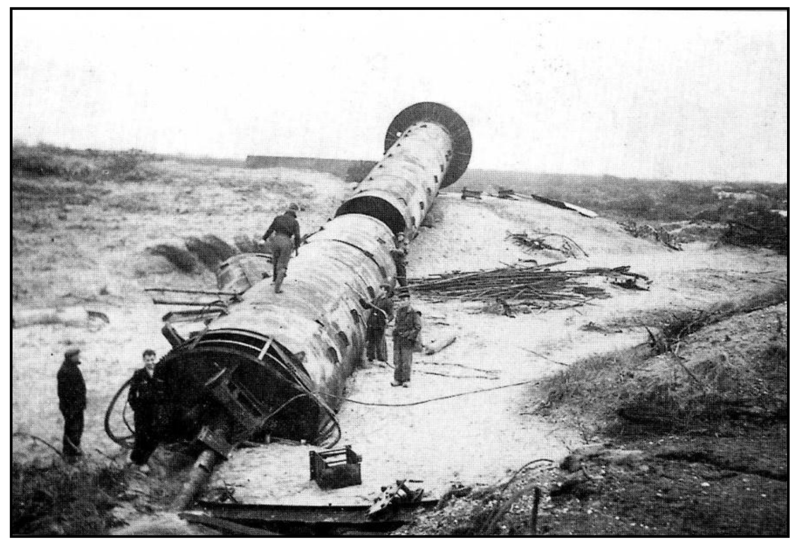


Stellung BIBER, Oostvoorne)

Klein Heidelberg







Radarstellung BIBER: Kustverdediging op Voorne 1940 – 1945, Jeroen Rijpsma and Klaas van Brakel, 2005

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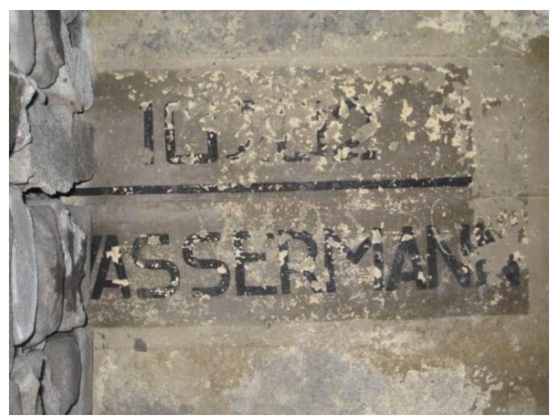


L480 Bunker (*Stellung* BIBER, Oostvoorne)

Klein Heidelberg

Stellung TAUSENDFUESSLER, Cherbourg

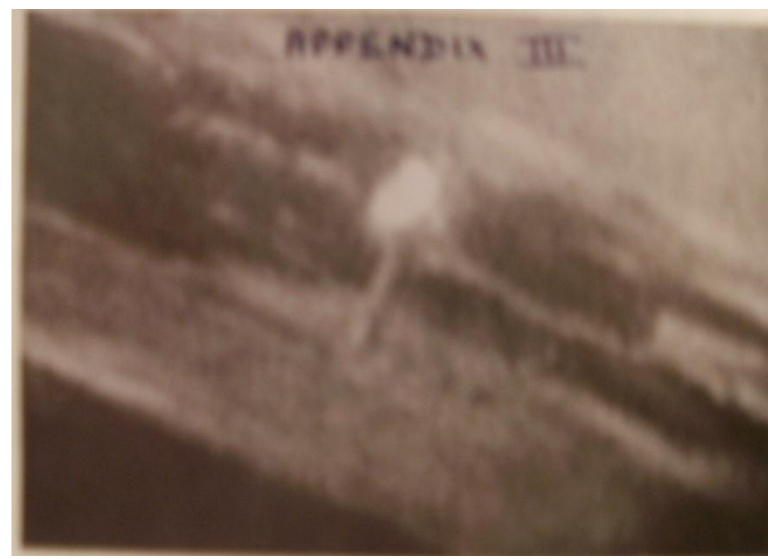
Klein Heidelberg

The Wassermann at De Haan was selected by R.V. Jones for an air attack, which took place on 16 March 1944, to demonstrate prior to the D-Day campaign that radar installations could successfully be destroyed by air attack.

The photos, from the gun cameras of the Typhoons of 198 Squadron, show the effect of the rocket projectiles.

This accords with Von Gregor’s account that ‘Just before the scheduled completion of the installation, the rotatable tower at de Haan was so seriously damaged in a heavy attack that it had to be dismantled and rebuilt’.

Also, they were puzzled that ‘… no signals have ever been intercepted, either before or after the attack, which could be traced to this particular radar’.



The curious case of Leutnant Künkel ...

- The curious unannounced inspection of the KH installation at Oostvoorne (BIBER) by a mysterious Luftwaffe ‘Leutnant Künkel’, whose papers were all in order but ‘no-one knew where he came from or where he went to’.

- An account of this visit is given in Hoffmann’s book, quoting from the report of Oberfeldwebel Schultze who was the Head of the KH base and equipment troop at BIBER. This reports that during a tour of the site, Künkel stated he was tasked to have KH measure the trajectories of the V-1 and V-2 rockets.

- Subsequently it was suggested that Künkel may have been a British spy or from the Resistance. To add to this mystery, Phil Judkins has suggested that the infiltrator might have been from one of the Communist networks rather than from London. Or that the Germans had several competing *internal* security networks (RSHA - *Reichssichersheithauptamt* - Reich Security Head Office) versus Gestapo ….), and thus the inspection was genuine, but the left hand did not know what the right hand was doing.

- R.V. Jones stated in a letter to Louis Brown that Künkel was ‘not one of his men and that knowledge of Klein Heidelberg’s function came from the analysis of communications traffic’.

Klein Heidelberg

Report from Flt/Lt Silversides, TRE Malvern:

. . . At the range of the Dutch/Belgium coast, i.e. about 100 miles, the field strength of C.H. pulses and their associated echoes is quite adequate to render the Heidelberg system workable.

. . . Given reasonable D/F facilities it would be quite possible to plot tracks of aircraft at path differences of up to 100 miles and probably up to path differences of 200 miles.

Results obtained at Knocke with a simple AE system and low gain receiver, were so good as to lead to the suggestion that the system might well be developed to extend the coverage of C.H. stations. From difficulties experienced the following requirements are put forward for an operational C.H. parasite:-

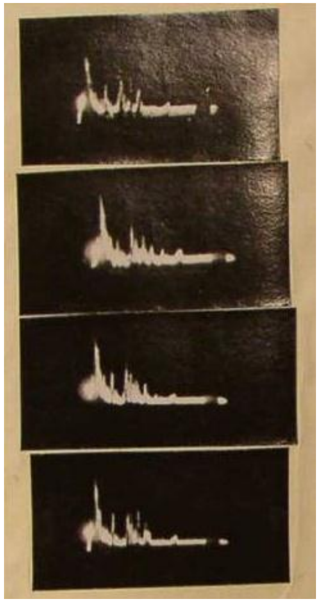
(i) Independent lock receiver and AE system. The lock receiver aerial to be bidirectional so that it may be turned towards the required parent C.H.

:

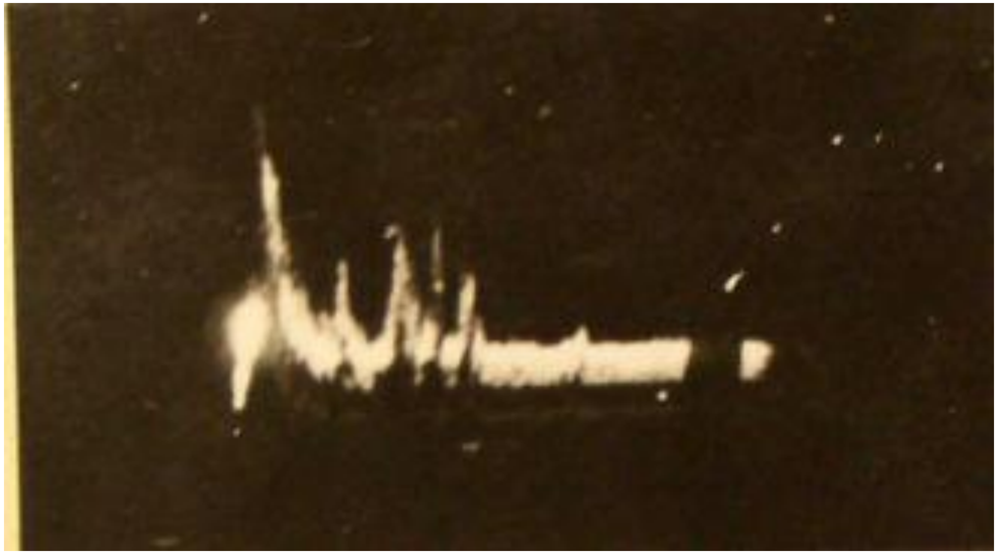
. . . With this system path differences and bearing would be obtained. A/c could then be plotted as intersection of bearing with appropriate path difference ellipse

Flt Lt Silversides, *Interim Report on Heidelberg Investigations Carried Out on the Belgium Coast between 24.1.45 & 10.2.45*, 17 February 1945.

Klein Heidelberg



Series of four photographs on 1000 μs triggered time-base showing changing echo pattern at intervals of 3 – 5 mins. Full trace represents path difference of approx. 150 miles.



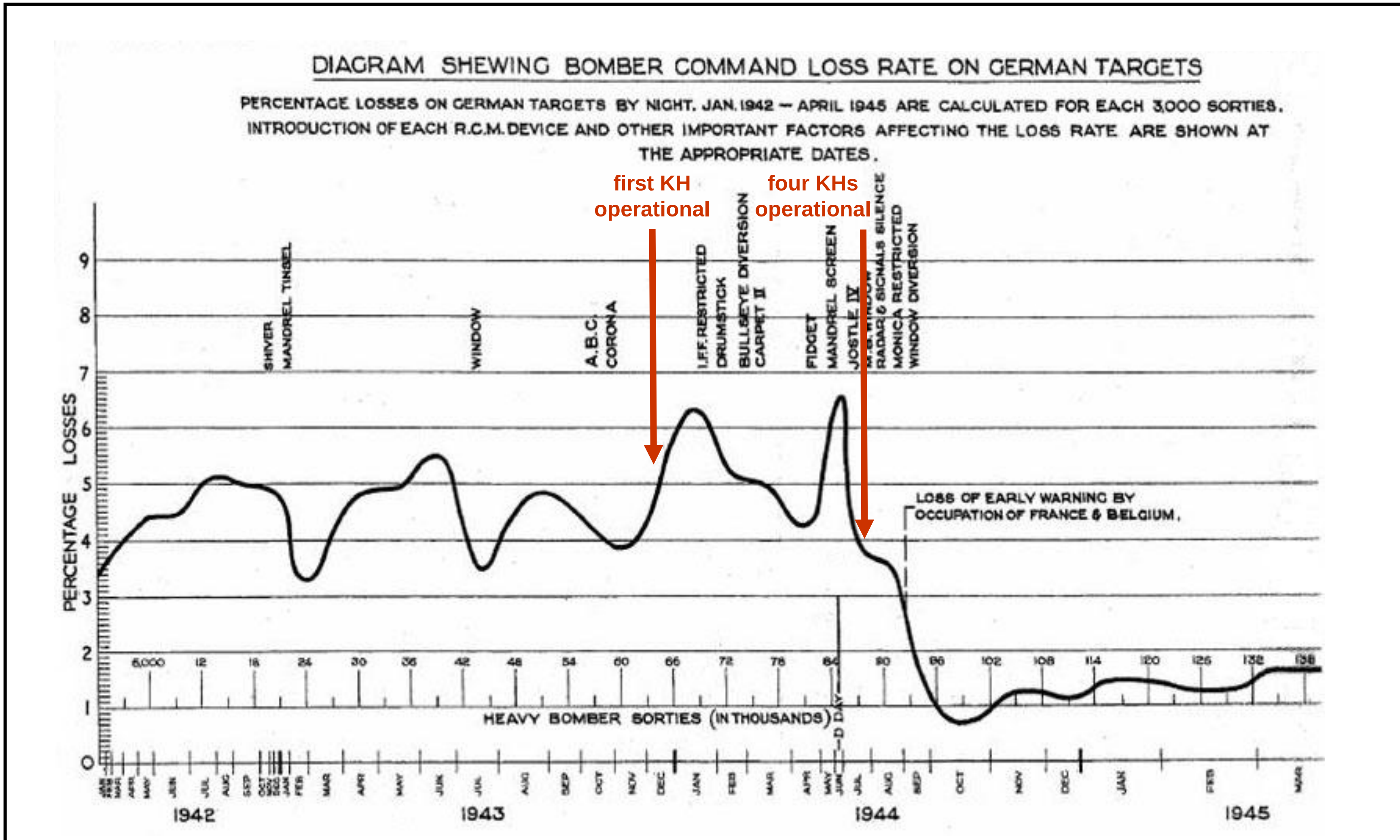
Flt Lt Silversides, *Interim Report on Heidelberg Investigations Carried Out on the Belgium Coast between 24.1.45 & 10.2.45*, 17 February 1945.

Countermeasures against KH

The *Air Scientific Intelligence Interim Report, Heidelberg* considers the issue of countermeasures against KH, and this was also discussed at a meeting at the Air Ministry on 19 March 1945. Options identified were:

1. Physical attack of the receiving stations.
2. PRF jittering – this was employed from ~ November 1944, making it more difficult for the KH receiver to synchronise to the CH transmissions. There are several indications that this was quite successful, at least initially.
3. Switch off the CH transmitters altogether for a few hours (this was given the codename BAFFLER). But it was pointed out that as well as interrupting the operation of the air defence system, including the capability of detecting V-2 rockets (BIG BEN), the air-sea rescue service depended on CH to locate and rescue downed aircrew. So it does not seem that this was ever implemented.
4. Repeater jammers (MOONSHINE) to generate large numbers of false targets.

Klein Heidelberg



War in the Æther: Radio Countermeasures in Bomber Command – an Historical Note, Signals Branch, Headquarters Bomber Command, 621.391.825 H, October 1945.

Summary

- Klein Heidelberg was the world's first proper bistatic radar system
- Its origins are not completely clear, but it had a number of clever features which anticipated many of our present ideas on bistatic radar – so it was several decades ahead of its time
- Several sources confirm that its detection range was impressive
- But it seems that it came into service too late to be genuinely significant
- Several of the ideas for countermeasures against bistatic radar are just as valid today
- Although TRE scientists carried out quite detailed trials of their own, it does not seem that the idea was pursued after the War